Federal Ministry for the
Environment, Nature Conservation,
Building and Nuclear Safety

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

Report of the Federal Republic of Germany for the Sixth Review Meeting
in May 2018

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List of Abbreviations

AGO	Arbeitsgruppe Option – Rückholung *Working group option – retrieval*
AKR	Ausbildungskernreaktor *Training reactor*
ALG	Abfalllager Gorleben *Gorleben waste storage facility*
AtAV	Atomrechtliche Abfallverbringungsverordnung *Nuclear Waste Shipment Ordinance*
AtG	Atomgesetz *Atomic Energy Act*
AtSMV	Atomrechtliche Sicherheitsbeauftragten- und Meldeverordnung *Nuclear Safety Officer and Reporting Ordinance*
AtVfV	Atomrechtliche Verfahrensverordnung *Nuclear Licensing Procedure Ordinance*
AVR	Arbeitsgemeinschaft Versuchsreaktor GmbH *Experimental nuclear reactor at Jülich*
AVV	Allgemeine Verwaltungsvorschrift *General administrative provision*
BAFA	Bundesamt für Wirtschaft und Ausfuhrkontrolle *Federal Office for Economic Affairs and Export Control*
BAM	Bundesanstalt für Materialforschung und –prüfung *Federal Institute for Materials Research and Testing*
BBK	Bundesamt für Bevölkerungsschutz und Katastrophenhilfe *Federal Office of Civil Protection and Disaster Assistance*
BER II	Berliner Experimentier-Reaktor II *Berlin experimental reactor II*
BfE	Bundesamt für kerntechnische Entsorgungssicherheit *Federal Office for the Safety of Nuclear Waste Management*
BfS	Bundesamt für Strahlenschutz *Federal Office for Radiation Protection*
BGBl.	Bundesgesetzblatt *Federal Law Gazette*
BGE	Bundes-Gesellschaft für Endlagerung mbH *Federal Company for Radioactive Waste Disposal*
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe *Federal Institute for Geosciences and Natural Resources*
BGZ	BGZ Gesellschaft für Zwischenlagerung mbH *Company for radioactive waste storage*
BMU	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (bis 17. Dezember 2013) *Federal Ministry for the Environment, Nature Conservation and Nuclear*

	Safety (until 17 December 2013)
BMUB	Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (ehem. BMU) *Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (formerly BMU)*
BMWi	Bundesministerium für Wirtschaft und Energie *Federal Ministry for Economic Affairs and Energy*
BNFL	British Nuclear Fuels plc
BWR	Boiling Water Reactor
BZA	Brennelement-Zwischenlager Ahaus GmbH *Fuel assembly storage facility at Ahaus*
CASTOR	Cask for Storage and Transport of Radioactive Material
CEA	Commissariat à l'énergie atomique et aux énergies alternatives
CSD-B	Colis Standard de Déchets - Boues *Standard package for intermediate level vitrified waste*
CSD-C	Colis Standard de Déchets – Compactés *Standard package for waste compacted under high pressure*
DAEF	Deutsche Arbeitsgemeinschaft Endlagerforschung *German association of repository research*
DBE	Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH *German service company for the construction and operation of waste repositories*
DIN	Deutsches Institut für Normung e. V. *German Institute for Standardization*
EAN	European Article Numbering
EIA	Environmental Impact Assessment
EndlagerVlV	Endlagervorausleistungsverordnung *Repository Prepayment Ordinance*
ERAM	Endlager für radioaktive Abfälle Morsleben *Morsleben repository for radioactive waste*
ESK	Entsorgungskommission *Nuclear Waste Management Commission*
EU	European Union
EURATOM	European Atomic Energy Community
EUROCHEMIC	European Company for the Chemical Processing of Irradiated Fuels
EVU	Energieversorgungsunternehmen *Electric power utility/utilities*
EWN	Entsorgungswerk für Nuklearanlagen GmbH (formerly Energiewerke Nord GmbH)
FA/FAs	Fuel Assembly/Fuel Assemblies
FBR	Fast Breeder Reactor
FINAS	Fuel Incident Notification and Analysis System
FR-2	Forschungsreaktor 2, Karlsruhe *Research Reactor 2, Karlsruhe*

FRG	Forschungsreaktor Geesthacht *Geesthacht research reactor*
FRJ	Forschungsreaktor Jülich *Jülich research reactor*
FRM	Forschungsreaktor München, Garching *Munich research reactor, Garching*
FRMZ	TRIGA-Reaktor, Mainz *TRIGA research reactor, Mainz*
FZJ	Forschungszentrum Jülich GmbH (früher KFA, heute JEN) *Jülich research centre (formerly KFA, now JEN)*
FZK	Forschungszentrum Karlsruhe GmbH (früher KfK, heute KIT) *Karlsruhe research centre (formerly KfK, now KIT)*
GDR	German Democratic Republic (see DDR)
GG	Grundgesetz *Basic Law for the Federal Republic of Germany*
GKN	Kernkraftwerk Neckarwestheim *Neckarwestheim nuclear power plant*
GMBl.	Gemeinsames Ministerialblatt *Joint Ministerial Gazette*
GNS	GNS Gesellschaft für Nuklear-Service mbH
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH
GSF	Gesellschaft für Strahlenforschung (heute HMGU) *Company for radiation research (now HMGU)*
HAW	High Active Waste
HAWC	High Active Waste Concentrate
HASS	High-Activity Sealed Radioactive Sources
HDB	Hauptabteilung Dekontaminationsbetriebe der KTE GmbH (ehemals WAK GmbH) *Central Decontamination Department of the KTE GmbH (formerly WAK GmbH)*
HDR	Heißdampfreaktor, Großwelzheim *Superheated steam reactor, Großwelzheim*
HLW	High Level Waste
HM	Heavy Metal
HMGU	Helmholtz Zentrum München – Deutsches Forschungszentrum für Gesundheit und Umwelt GmbH (früher GSF) *German Research Center for Environmental Health (formerly GSF)*
HTGR	High Temperature Gas-Cooled Reactor
HTR	High Temperature Reactor
HWGCR	Heavy Water Gas-Cooled Reactor
HZB	Helmholtz-Zentrum Berlin
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IEC	International Electrotechnical Commission

ILW	Intermediate Level Waste
IMIS	Integriertes Mess- und Informationssystem zur Überwachung der Umweltradioaktivität *Integrated Measuring and Information System for monitoring environmental radioactivity*
INES	International Nuclear Event Scale
INEX	International Nuclear Emergency Exercise
ISO	International Organization for Standardization
ITU	Institute for Transuranium Elements, Karlsruhe (now Joint Research Center)
JEN	Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH
KBR	Kernkraftwerk Brokdorf *Brokdorf nuclear power plant*
KFA	Kernforschungsanlage Jülich (now JEN)
KfK	Kernforschungszentrum Karlsruhe (now Karlsruher Institut für Technologie, KIT)
KFK	Kommission zur Überprüfung der Finanzierung des Kernenergieausstiegs *Commission to Review the Financing for the Phase-out of Nuclear Energy*
KGR	Kernkraftwerk Greifswald *Greifswald nuclear power plant*
KIT	Karlsruher Institut für Technologie *Karlsruhe Institute of Technology*
KKB	Kernkraftwerk Brunsbüttel *Brunsbüttel nuclear power plant*
KKE	Kernkraftwerk Emsland *Emsland nuclear power plant*
KKG	Kernkraftwerk Grafenrheinfeld *Grafenrheinfeld nuclear power plant*
KKI	Kernkraftwerk Isar *Isar nuclear power plant*
KKK	Kernkraftwerk Krümmel *Krümmel nuclear power plant*
KKN	Kernkraftwerk Niederaichbach *Niederaichbach nuclear power plant*
KKP	Kernkraftwerk Philippsburg *Philippsburg nuclear power plant*
KKR	Kernkraftwerk Rheinsberg *Rheinsberg nuclear power plant*
KKS	Kernkraftwerk Stade *Stade nuclear power plant*
KKU	Kernkraftwerk Unterweser *Unterweser nuclear power plant*
KMK	Kernkraftwerk Mülheim-Kärlich (heute Anlage Mülheim-Kärlich) *Mülheim-Kärlich nuclear power plant (now Mülheim-Kärlich plant)*
KNK II	Kompakte Natriumgekühlte Kernreaktoranlage, Karlsruhe *Compact sodium-cooled nuclear reactor plant, Karlsruhe*

KRB	Kernkraftwerk Gundremmingen *Gundremmingen nuclear power plant*
KTA	Kerntechnischer Ausschuss *Nuclear Safety Standards Commission*
KTE	Kerntechnische Entsorgung Karlsruhe GmbH (until 7 February 2017 Wiederaufbereitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH)
KWB	Kernkraftwerk Biblis *Biblis nuclear power plant*
KWG	Kernkraftwerk Grohnde *Grohnde nuclear power plant*
KWL	Kernkraftwerk Lingen *Lingen nuclear power plant*
KWO	Kernkraftwerk Obrigheim *Obrigheim nuclear power plant*
KWU	Kraftwerk Union AG
KWW	Kernkraftwerk Würgassen *Würgassen nuclear power plant*
LAA	Länderausschuss für Atomkernenergie *Länder Committee for Nuclear Energy*
LAW	Low Active Waste
LLW	Low Level Waste
LWR	Light-Water Reactor
MAW	Medium Active Waste
MLU	Ministerium für Landwirtschaft und Umwelt (Sachsen-Anhalt) *Ministry of Agriculture and the Environment of Saxony-Anhalt*
MOX	Mixed Oxide
MTR	Materialtestreaktor *Material testing reactor*
MWe	Megawatts electrical
MWEIMH	Ministerium für Wirtschaft, Energie, Industrie, Mittelstand und Handwerk des Landes Nordrhein-Westfalen *Ministry of Economic Affairs, Energy, Industry, SMEs and Crafts of North Rhine-Westphalia (now MWIDE)*
MWIDE	Ministerium für Wirtschaft, Innovation, Digitalisierung und Energie des Landes Nordrhein-Westfalen (früher MWEIMH) *Ministry of Economic Affairs, Innovation, Digitization and Energy of North Rhine-Westphalia (formerly MWEIMH)*
MZFR	Mehrzweckforschungsreaktor, Karlsruhe *Multi-purpose research reactor, Karlsruhe)*
NCS	Nuclear Cargo + Service GmbH
NDA	Nuclear Decommissioning Authority
NEA	Nuclear Energy Agency
NEZ	Nukleares Entsorgungszentrum *Nuclear waste management centre)*
NMU	Niedersächsisches Ministerium für Umwelt, Energie und Klimaschutz

	(*Lower Saxony Ministry for the Environment, Energy and Climate Protection)*
NORM	Naturally Occurring Radioactive Material
NPP	Nuclear Power Plant
OECD	Organisation for Economic Co-operation and Development
PETRA	Pellet-Trocknungsanlage *Pellet drying facility*
PKA	Pilot-Konditionierungsanlage, Gorleben *Pilot conditioning plant, Gorleben*
PSR	Periodic Safety Review
PWR	Pressurised Water Reactor
QK	Qualitätsklasse – Konventionell *Quality class – conventional*
QN	Qualitätsklasse – Nuklear *Quality class – nuclear*
RDB	Reactor Pressure Vessel
REI	Richtlinie zur Emissions- und Immissionsüberwachung kerntechnischer Anlagen *Guideline concerning Emission and Immission Monitoring of Nuclear Installations*
RFR	Rossendorfer Forschungsreaktor *Rossendorf research reactor*
RöV	Röntgenverordnung *X-Ray Ordinance*
RSK	Reaktor-Sicherheitskommission *Reactor Safety Commission*
RWTH	Rheinisch-Westfälische Technische Hochschule Aachen
SAAS	Staatliches Amt für Atomsicherheit und Strahlenschutz *State board for atomic safety and radiation protection*
SKB	Svensk Kärnbränslehantering AB *Swedish Nuclear Fuel and Waste Management Company*
SSK	Strahlenschutzkommission *Commission on Radiological Protection*
StandAG	Standortauswahlgesetz *Repository Site Selection Act*
STEAG	Steinkohlen-Elektrizität AG
StGB	Strafgesetzbuch *Criminal Code*
StrlSchG	Strahlenschutzgesetz *Radiation Protection Act*
StrlSchV	Strahlenschutzverordnung *Radiation Protection Ordinance*
StrVG	Strahlenschutzvorsorgegesetz *Precautionary Radiation Protection Act*
SUR	Siemens-Unterrichtsreaktor

	Siemens research reactor designed for training purposes
SZS	Staatliche Zentrale für Strahlenschutz *State office for radiation protection*
TBL	Transportbehälterlager *Transport cask storage facility*
TBL-A	Transportbehälterlager Ahaus *Ahaus transport cask storage facility*
TBL-G	Transportbehälterlager Gorleben *Gorleben transport cask storage facility*
THTR	Thorium-Hochtemperaturreaktor, Hamm-Uentrop *Thorium high-temperature reactor, Hamm-Uentrop*
TRIGA	Training, Research and Isotope Production Facility of General Atomic (Reactor)
TWh	Terawatt-hour
US-DOE	United States Department of Energy
US-NRC	United States Nuclear Regulatory Commission
UVPG	Gesetz über die Umweltverträglichkeitsprüfung *Environmental Impact Assessment Act*
VAK	Versuchsatomkraftwerk Kahl *Kahl experimental nuclear power plant*
VBA	Verlorene Betonabschirmung *Lost concrete shielding*
VEK	Verglasungseinrichtung Karlsruhe *Karlsruhe vitrification plant*
VKTA	Strahlenschutz, Analytik und Entsorgung Rossendorf e. V. (bis Dezember 2014 Verein für Kernverfahrenstechnik und Analytik Rossendorf e. V.) *Radiation Protection, Analytics & Disposal Inc. (until December 2014 Nuclear Engineering and Analytics Rossendorf Inc.)*
VLLW	Very Low Level Waste
VOAS	Verordnung über die Gewährleistung von Atomsicherheit und Strahlenschutz Ordinance on Nuclear Safety and Radiation Protection
VVER	Water-cooled and water-moderated energy reactor (Soviet design)
WAK	Wiederaufarbeitungsanlage Karlsruhe *Karlsruhe reprocessing plant*
WENRA	Western European Nuclear Regulators' Association
WGWD	WENRA Working Group on Waste and Decommissioning
WHG	Wasserhaushaltsgesetz *Federal Water Act*
WTI	Wissenschaftlich-Technische Ingenieurberatung GmbH
ZLN	Zwischenlager Nord, Rubenow

Summary

Status of power and research reactors in Germany

There are currently eight power reactors in operation in Germany. These are exclusively light water reactors (six pressurised water reactors and two boiling water reactors) whose fuel assemblies are composed of low-enriched uranium oxide or uranium/plutonium mixed oxide (MOX). With the entry into force of the Thirteenth Act Amending the Atomic Energy Act [1A-25] on 6 August 2011 as a result of the events in Japan, the authorisation for power operation for the eight nuclear power plants Biblis Unit A and Unit B, Neckarwestheim I, Brunsbüttel, Isar 1, Unterweser, Philippsburg 1 and Krümmel expired. For the eight nuclear power plants shut down in 2011, applications for decommissioning and dismantling were filed. Until granting of a decommissioning licence, these nuclear power plants are in the post-operational phase. The decommissioning and dismantling licences according to § 7(3) Atomic Energy Act (AtG) [1A-3] were granted for Isar 1 on 17 January 2017, for Neckarwestheim I on 3 February 2017, for the nuclear power plants Biblis Unit A and Unit B on 30 March 2017, and for Philippsburg 1 on 7 April 2017. According to the AtG, the authorisation for power operation of the Grafenrheinfeld nuclear power plant (KKG) would have expired by 31 December 2015. On 27 June 2015, the KKG has been finally taken off the grid. Applications for decommissioning and dismantling were filed on 28 March 2014. The electric power utilities E.ON (now PreussenElektra GmbH), RWE and Vattenfall have filed a constitutional complaint against the amendment of the Atomic Energy Act. By judgement of 6 December 2016, the Federal Constitutional Court confirmed that the phase-out of nuclear energy enacted in 2011 is, in essence, consistent with the constitution. Both the introduction of fixed dates by which the nuclear power plants must be shut down and staggering of these dates, as well as the revocation of the lifetime extension of 2010 without compensation and the legislative procedure itself were classified as constitutional. For the eight nuclear power plants still in operation, the authorisation for power operation will expire successively between the end of 2017 and the end of 2022. Another 21 reactors (including experimental and demonstration reactors) are in the process of being decommissioned and for three reactors decommissioning has been completed.

In Germany, there are currently three research reactors (the Berlin experimental reactor II (BER II), the Research Neutron Source Heinz Maier-Leibnitz (FRM II) of the Technical University of Munich, the TRIGA Mark II research reactor in Mainz), three reactors for training purposes and one reactor for educational purposes in operation. Six research reactors are in the process of being decommissioned and four research reactors were permanently shut down. For 28 research reactors, decommissioning has been completed.

Spent fuel management facilities

The following facilities shall be considered as spent fuel management facilities within the meaning of the Joint Convention:

- the on-site storage facilities of nuclear power plants,
- the central storage facilities in Ahaus, Gorleben and Rubenow,
- the AVR cask storage facility in Jülich,
- the pilot conditioning plant in Gorleben.

(1) On-site storage facilities

Decentralised storage facilities for spent fuel were licensed under nuclear law and constructed and commissioned at twelve sites with nuclear power plants. They are designed as dry storage facilities in which transport and storage casks loaded with spent fuel are emplaced.

The storage facilities are cooled by passive air convection which removes the heat from the casks independently of any active technical systems. The leak-proof and accident-resistant casks ensure safe enclosure as well as the necessary degree of radiation shielding and criticality safety during both normal operation and in the case of various incidents or accidents. Protection against external hazards, such as earthquakes, blast waves and aircraft crashes, is ensured by the thick walls of the casks. It was demonstrated and confirmed in the licensing procedure that the casks are suitable for at least 40 years of storage. Thus, the licences currently limit the storage period to 40 years, starting with the emplacement of the first cask. An extension of this time period requires a new licence. According to § 6(5) AtG, the licences may only be renewed on imperative grounds and after this issue has been discussed in the German *Bundestag*.

(2) Central storage facilities

Storage casks for spent fuel in the central storage facilities have the same properties as the storage casks in on-site storage facilities.

Gorleben transport cask storage facility

The Gorleben transport cask storage facility is licensed for the storage of nuclear fuel in the form of spent fuel assemblies from light water reactors as well as of HAW canisters (vitrified high level fission product solutions from reprocessing of German fuel assemblies). The latest modification licence from 2010 allows storage in casks of the newer type CASTOR® HAW 28M. The storage facility is designed as a dry storage facility.

Due to the amendments to the Atomic Energy Act resulting from the entry into force of the Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste and for the Amendment of Other Laws (Repository Site Selection Act – StandAG) [1A-7a], the remaining high level waste from the reprocessing of German spent fuel abroad must be stored in local storage facilities. For conditioned radioactive waste with negligible heat generation which is currently stored in the Gorleben waste storage facility, storage in a separate section within the transport cask storage facility was applied for in December 2013.

Ahaus transport cask storage facility

According to the licence granted, spent fuel from various German nuclear power plants may be stored in the Ahaus transport cask storage facility. In addition, the Ahaus transport cask storage facility is also licensed as a central storage facility for the storage of transport and storage casks of the CASTOR® THTR/AVR and MTR 2 types, in which spent fuel from experimental, demonstration and research reactors is stored. It is therefore intended to use the Ahaus cask storage facility also for the storage of further spent fuel from research reactors (the Berlin experimental reactor II (BER II), the Research Neutron Source Heinz Maier-Leibnitz (FRM II) of the Technical University of Munich, the TRIGA Mark II research reactor in Mainz) in casks of the CASTOR® MTR 3 type. By letter of 30 September 2014, the Gesellschaft für Nuklear-Service mbH (GNS) asked for resuming the nuclear licensing procedure for the storage of the spent fuel from the FRM II of the Technical University of Munich in the Ahaus transport cask storage facility.

By letter of 24 September 2009, the Brennelement-Zwischenlager Ahaus GmbH (BZA) and GNS filed an application at the Federal Office for Radiation Protection (BfS) according to § 6 of the Atomic Energy Act (AtG) [1A-3] for the storage of nuclear fuel in the form of spent fuel elements and other radioactive material in the form of operational elements (absorber and graphite elements with no fissile material content) from the former experimental reactor at Jülich (AVR) of the Arbeitsgemeinschaft Versuchsreaktor GmbH, in a total of 152 transport and storage casks of the CASTOR® THTR/AVR type in the eastern part of the two storage areas (storage area II), which is currently stored in the AVR cask storage facility at the site of the Forschungszentrum Jülich GmbH (FZJ). After interim suspension of the licensing procedure, it was resumed in January 2015 and concluded by the BfS on 21 July 2016 with the granting of the 8th modification licence for the Ahaus transport cask storage facility.

Furthermore, the storage of high-pressure compacted radioactive waste (the CSD-C from reprocessing at La Hague) in the Ahaus transport cask storage facility was applied for. Currently, a cask concept for 27 canisters each is under development.

On 9 November 2009, the district government of Münster granted a licence according to § 7 of the Radiation Protection Ordinance (StrlSchV) [1A-8] for the temporary storage of waste from operation and decommissioning in the western part of the two storage areas (storage hall I) of the Ahaus transport cask storage facility. The storage period is limited to ten years.

Zwischenlager Nord (ZLN)

In addition to spent fuel from the Soviet-type reactors at Rheinsberg and Greifswald, spent and fresh fuel from the compact sodium-cooled nuclear reactor plant (KNK II), from the nuclear ship Otto Hahn as well as HAW glass canisters with high level waste from the Karlsruhe reprocessing plant (WAK) are currently stored in the Rubenow dry storage facility (ZLN). The KNK fuel rods were emplaced in 2010, the HAW glass canisters in 2011.

(3) AVR cask storage facility in Jülich

In the AVR cask storage facility in Jülich, the spent fuel spheres from the operation of the experimental reactor at Jülich (AVR) are stored in 152 transport and storage casks of the CASTOR® THTR/AVR type. The original storage licence granted by the BfS on 17 June 1993 had been limited to 20 years. On 26 June 2007 and with a more precise letter dated 29 April 2009, the FZJ applied for the storage of AVR fuel elements in the Jülich storage facility for another three years from 1 July 2013. After the FZJ had asked to suspend the licensing procedure on 16 July 2010, the BfS resumed the procedure at the FZJ's request of 16 May 2012 and has been continuing it since then. On the part of the applicant, the licensing procedure has been led by the Arbeitsgemeinschaft Versuchsreaktor GmbH since 1 September 2015, which was merged with the nuclear areas of the FZJ as of 1 September 2015 into the new Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH (JEN).

After expiry of the storage licence of 1993 on 1 July 2013 the licence for continued operation of the AVR cask storage facility that had been applied for could not be granted yet by the BfS. Therefore, the then Ministry of Economic Affairs, Energy, Industry, SMEs and Crafts of North Rhine-Westphalia (MWEIMH), as the competent nuclear supervisory authority, issued temporary orders on 27 June 2013 and 17 December 2013 on the basis of the general licensability of the licence applied for at the BfS for the further storage of the nuclear fuel from the AVR in the AVR cask storage facility in Jülich. It was not possible to conclude the licensing procedure until expiry of the second storage order on 31 July 2014 either, since the safety demonstrations with regard to seismic safety could not be provided within the licensing procedure. Consequently, on 2 July 2014, the nuclear supervisory authority gave order to remove the nuclear fuel from the AVR cask storage facility, and the previous order of 17 December 2013 was suspended.

The operator developed a concept for the removal of the fuel from the facility according to specific requirements from the order and presented it to the competent authority. This concept provides for three options, whose sequence in which they are presented does not imply a priority listing from the technical view:

1. transport of the nuclear fuel to the Ahaus transport cask storage facility,
2. transport of the nuclear fuel to their country of origin, the United States of America, and
3. transport of the nuclear fuel to a new storage facility to be built at the Jülich site.

The nuclear supervisor has commissioned an authorised expert according to § 20 AtG as well as a legal expert with the assessment of the concept in the sense of a plausibility check of the described processes, in particular with regard to issues related to safety and security, and with a legal assessment with regard to issues related to nuclear, environmental, transport and hazardous goods law.

Due to the extent and complexity of the issues to be examined, none of the three options is ready for decision yet. Government custody according to § 5 AtG can be ruled out.

On 21 July 2016, the BfS granted the operator of the Ahaus storage facility the licence according to § 6 AtG for emplacement of the 152 casks of the CASTOR® THTR/AVR type, which are currently stored in Jülich. A transport of the casks from Jülich to Ahaus requires a transport licence according to § 4 AtG. It is not yet foreseeable when the licence can be granted.

(4) Pilot conditioning plant (PKA) Gorleben

The reference concept for direct disposal of spent fuel in a salt dome pursued until the entry into force of the StandAG [1A-7a] envisaged the removal of the fuel rods from the fuel assemblies in an above-ground facility, the packaging of the fuel rods in self-shielding and sealed thick-walled casks and their emplacement in deep geological formations for disposal. In accordance with the type of cask used, it is referred to as the POLLUX reference concept. In order to demonstrate the conditioning technique, a pilot conditioning plant (PKA) was completed in Gorleben in 2000. The plant is licensed for a throughput of 35 Mg HM/a. According to the agreement between the Federal Government and the utilities of 11 June 2001, the use of the plant is licensed only for the repair of defective casks for spent fuel from light water reactors and for vitrified HAW from reprocessing as well as for the handling of other radioactive material.

Spent fuel management policy

Since the 1990s, Germany's objective regarding the management of spent fuel has changed. Until 1994, the Atomic Energy Act (AtG) [1A-3] included the requirement of reusing the fissile material in the spent fuel. This requirement changed in 1994, and the operators of nuclear power plants then had the option of either reuse by means of reprocessing, or else of direct disposal.

Since 1 July 2005, delivery of spent fuel from commercial electricity production for the purposes of reprocessing has been prohibited in accordance with an amendment of the Atomic Energy Act to this effect of 22 April 2002 [1A-2]. The last spent fuel to be delivered for reprocessing was dispatched from the Stade nuclear power plant (KKS) in May 2005. Now, only the direct disposal of the spent fuel that exists and will be generated in future in Germany as radioactive waste is permissible.

For the spent fuel which had been delivered for reprocessing, the proof of reuse of the plutonium separated during reprocessing must be kept. This is to ensure that throughout the remaining residual operating lives of the nuclear power plants, all separated plutonium will be processed in the fabrication of MOX fuel and thus be reused.

As there is as yet no repository available for the spent fuel, it will generally be stored; corresponding storage capacities exist as needed.

After the amendment to the AtG according to the Act Amending the Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste and for the Amendment of Other Laws (StandAG) [1A-7b], export of spent fuel from research reactors is only permitted for serious reasons of non-proliferation of nuclear fuel or for reasons of a sufficient supply of fuel elements for medical and other top level research purposes. An exception to this is the shipment of such fuel assemblies with the aim of producing waste packages that are suitable for disposal and that are to be disposed of in Germany. An export licence shall not be granted if the spent fuel is already stored in Germany pursuant to § 6 AtG.

As at 31 December 2016, a total of 15,155 Mg HM in the form of spent fuel assemblies has been produced in Germany. Of these, a total of 8,485 Mg HM are stored on-site in the fuel pools of the nuclear power plants, or in the central and decentralised storage facilities. 6,343 Mg HM were reprocessed mostly in other European countries, and 327 Mg HM were otherwise managed.

Radioactive waste management policy and practices

In Germany, disposal in deep geological formations is intended for all types of radioactive waste.

For the selection of a repository site for heat-generating radioactive waste, the Repository Site Selection Act (StandAG) [1A-7a] was adopted, which entered into force on 27 July 2013.

Prior to the actual site selection procedure, the Commission on the Storage of High-Level Radioactive Waste examined and assessed the relevant fundamental issues for the selection procedure with regard to radioactive waste management. In addition, the Commission evaluated the StandAG [1A-7a] and submitted proposals for its amendment. The *Bundestag* and the *Bundesrat* examined the recommendations of the Commission and considered them in the Act on the Reorganisation of the Organisational Structure in the Field of Disposal [1A-30] and in the Act Amending the StandAG [1A-7b], which largely entered into force on 16 May 2017 (see Chapter E.2.2 for details on the Act on the Reorganisation of the Organisational Structure in the Field of Disposal as well as on the Repository Site Selection Act).

Only solid (or solidified) radioactive waste will be accepted for disposal in deep geological formations; liquid and gaseous waste is excluded from acceptance. The controlled, safe disposal of radioactive waste therefore requires its conditioning.

Proven methods and reliable mobile or stationary installations already exist for the pretreatment and conditioning of radioactive waste. In addition to German facilities, facilities in other European countries are also utilised for waste management.

Both central and decentralised storage facilities are available for the storage of radioactive waste with negligible heat generation from nuclear power plants and the nuclear industry. For waste from the use and handling of radioisotopes in research, industry and medicine, *Land* collecting facilities operated by the *Länder* are available for storage.

Due to the current licensing situation, heat-generating radioactive waste may be kept in storage in decentralised and central storage facilities. Waste from the reprocessing of spent fuel from German nuclear power plants is conditioned in France and the United Kingdom (e.g. vitrification of the high-level fission product solutions) and is then returned to Germany. Until the end of 2013, the Gorleben storage facility was provided for the storage of vitrified waste. As stipulated in the Atomic Energy Act (AtG) [1A-3], solidified fission product solutions from reprocessing abroad shall be taken back and stored in local storage facilities. According to § 6(5) AtG, the storage of nuclear fuel in storage facilities shall not exceed 40 years starting from the emplacement of the first cask.

For radioactive waste with negligible heat generation, compliance of the packages with the requirements set out in the acceptance criteria of the repository is reviewed within the scope of a product control. For this, the acceptance criteria of the Konrad repository, which is plan-approved and is under construction, are relevant. The product control measures relate both to radioactive waste that has already been conditioned and to radioactive waste that will be conditioned in the future. These are designed in such a way that reliable identification of waste packages that do not conform to the specifications is ensured.

As at 31 December 2016, a total of 120,322 m³ (gross volume) of radioactive waste with negligible heat generation in containers was stored in Germany. The waste originated primarily from research institutions, nuclear power plants and the nuclear industry including reprocessing as well as from medical applications and the non-nuclear industry. In addition to the spent fuel, a total of 577 m³ of heat-generating radioactive waste was stored, which mainly consists of vitrified high level waste from reprocessing. From 1967 to 1978, a total of 124,494 packages were emplaced in the Asse II mine as low level waste, including also, in the case of higher activities, those with so-called lost concrete shieldings. In addition, 1,293 drums and packages with intermediate level waste were emplaced. The gross volume of the packages is about 47,000 m³. By the end of 2016, a total of 37,158 m³ of solid low and intermediate level waste and 6,621 sealed sources were disposed of in the Morsleben repository for radioactive waste (ERAM). This includes the operational waste that has been produced since 1998 by keeping the repository open.

Criteria used to define and categorise radioactive waste

Since disposal in deep geological formations is intended for all types of radioactive waste, there is no need to differentiate between waste containing radionuclides with comparatively short half-lives and waste containing radionuclides with comparatively long half-lives. Thus, there are no measures or precautions required in order to separate the radioactive waste produced in this respect.

In order to meet the requirements concerning the registration and categorisation of radioactive waste from the point of view of disposal, it has been decided to refrain from using the terms LLW, ILW and HLW and to choose a new classification instead, which was made under particular consideration of aspects relevant for disposal and is based on the intention to dispose of all types of radioactive waste in deep geological formations. Accordingly, waste is initially subjected to a basic subdivision into

- heat-generating radioactive waste and
- radioactive waste with negligible heat generation

which is then further subdivided according to the categorisation scheme established for this purpose.

Heat-generating radioactive waste is characterised by high activity concentrations and thus by a high decay heat. It comprises, in particular, the vitrified fission product concentrate, hulls, structural components and feed sludge from the reprocessing of spent fuel, and the spent fuel itself if it is to be disposed of directly as radioactive waste.

Types of waste with significantly lower activity concentrations from the operation, decommissioning and dismantling of nuclear facilities and installations as well as from the application of radioisotopes are classified among the radioactive waste with negligible heat generation. These are e.g. disused plant components and defective components such as pumps or piping, ion exchange resins and air filters from waste water and exhaust air decontamination, contaminated tools, protective clothing, decontamination and cleaning agents, laboratory waste, sealed radioactive sources, sludges, suspensions, oils as well as contaminated and activated concrete structures and debris.

Responsibility for the management of spent fuel and radioactive waste

The management of spent fuel and radioactive waste is based on the polluter-pays principle. According to § 9a(1) AtG [1A-3], the producers of radioactive residues are required to ensure that these are utilised without detrimental effects or are disposed of as radioactive waste in a controlled manner. This means that, as a general principle, the producers are responsible for the conditioning and storage of the spent fuel and the radioactive waste. According to the Waste Management Transfer Act, Article 2 of the Act on the Reorganisation of Responsibility in Nuclear Waste Management [1A-31], which entered into force on 16 June 2017, the radioactive waste from operation and decommissioning, safe enclosure as well as dismantling of nuclear fission facilities for the commercial production of electricity can be transferred to a third party (BGZ Gesellschaft für Zwischenlagerung mbH) commissioned with storage management by the Federation. The conditions for this are that the basic amount payable according to § 7(2) of the Waste Management Fund Act (Article 1 of the Act on the Reorganisation of Responsibility in Nuclear Waste Management) or the first instalment according to an agreement on payment in instalments effective under the Waste Management Fund Act were payed to the foundation *"Fonds zur Finanzierung der kerntechnischen Entsorgung"* (fund for the financing of nuclear waste management) and certain requirements are fulfilled in accordance with the Waste Management Transfer Act.

According to § 9a(2) AtG, anyone possessing radioactive waste must deliver it to a repository or to a *Land* collecting facility. With the delivery of radioactive waste to a *Land* collecting facility, the ownership is transferred to this facility. Thus, the responsibility for conditioning is assumed by the operator of the *Land* collecting facility. According to § 9a(3) AtG, the *Länder* shall establish collecting facilities for the storage of radioactive waste from research, medicine and industry produced within their territory. The producers of radioactive waste from the use of nuclear energy for electricity production are responsible for its conditioning and for its storage if spent fuel and radioactive waste have not been delivered or storage facilities have not been transferred to the Federation according to the Waste Management Transfer Act. According to § 9a(3) AtG, the Federation shall establish facilities for the disposal of radioactive waste and shall assign its duties to a third party. This third party is the federally-owned private-law company Bundes-Gesellschaft für Endlagerung mbH (BGE) whose sole shareholder is the Federation. The on-site facilities for the storage of nuclear fuel are operated by the electric power utilities and the central storage facilities in Ahaus and Gorleben by a subsidiary of the utilities, supervised by the *Länder* and licensed by the Federal Office for the Safety of Nuclear Waste Management (BfE). The Zwischenlager Nord (ZLN) and the AVR cask storage facility in Jülich are the responsibility of the public sector. According to the Waste Management Transfer Act, the storage facilities for heat-generating radioactive waste defined therein will be transferred with effect from 1 January 2019 and the storage facilities for radioactive waste with negligible heat generation with effect from 1 January 2020 from the current operators to a third party commissioned with storage management by the Federation, which is to be organised in private legal form and whose sole shareholder is the Federation (i.e. the BGZ Gesellschaft für Zwischenlagerung mbH).

The Federal Office for the Safety of Nuclear Waste Management (BfE) is also responsible for plan approval and licensing of disposal facilities; transitional provisions apply to the Konrad repository and the ERAM, according to which the *Länder* remain responsible for licensing until this responsibility is transferred to the BfE with the granting of the approval of commissioning by the nuclear supervisory authority for the Konrad repository or until the plan approval decision on decommissioning will be enforceable for the ERAM. Licensing and supervision of other waste management facilities is the responsibility of the *Länder*, as defined in § 24 AtG.

Financing of spent fuel and radioactive waste management

The polluter-pays principle also applies to the financing of spent fuel and radioactive waste management activities. Exceptions are the ERAM and the Asse II mine, whose costs are borne by the Federation. To date, the Federation has refinanced the necessary expenses for the planning and construction of the repositories through advance payments by the waste producers on contributions for these purposes.

According to the Waste Management Fund Act, Article 1 of the Act on the Reorganisation of Responsibility in Nuclear Waste Management [1A-31], in future, the financial obligations of the operators of the nuclear power plants defined in the Act will be transferred to the foundation *“Fonds zur Finanzierung der kerntechnischen Entsorgung“* (fund for the financing of nuclear waste management) upon payment of the basic amount by the operators pursuant to § 7(2) of the Waste Management Fund Act or the first instalment according to an agreement on payment in instalments effective under the Waste Management Fund Act. This includes also the cost allocations for the site selection procedure according to §§ 28 et seq. StandAG [1A-7a]. Thus, the waste management steps of storage and disposal will in future be financed from the fund.

The use of *Land* collecting facilities is refinanced by costs (fees and expenses) or charges, respectively, that are payable by the party delivering radioactive waste.

As the surveillance of a repository after its sealing is a governmental task, the necessary funds are provided by the Federation.

Legislative and regulatory framework in the area of spent fuel and radioactive waste management

The Federal Republic of Germany is a federal state. The responsibilities for law making and law enforcement are assigned differently to the organs of the Federation and the *Länder* according to the respective regulatory duties. Specifications are regulated by the provisions in the Basic Law of the Federal Republic of Germany.

The legislative competence for the use of nuclear energy for peaceful purposes lies with the Federation. The further development of nuclear law is also a task of the Federation. The *Länder* will be involved in the procedure dependent on the subject matter.

The Atomic Energy Act and the statutory ordinances based thereon are implemented by authorities of the Federation and the *Länder*, where many implementation tasks are executed by the *Länder* on behalf of the Federation. With respect to the legality and appropriateness of their action, the competent *Land* authorities are subject to supervision by the Federation.

Assurance of the safe handling of disused sealed sources

Nearly 100,000 sealed radioactive sources are used in research, trade, industry, medicine and agriculture in Germany. The most common fields of application for radioactive sources in the industry are calibration of measuring devices, materials testing, irradiation and sterilisation of products, as well as level and density measurements. In medicine, radioactive sources are mostly used for radiotherapy and for irradiation of blood. The most frequently used radionuclides in radioactive sources are Co-60, Ir-192, Cs-137, Sr-90 and Am-241 whose activity is in the range of some kBq for test and calibration sources and up to some TBq for radioactive sources for irradiation facilities. In Germany, the safety and security of disused sealed sources is ensured by a legal framework in accordance with European and international standards and by an extensive system of licensing and supervision. In the vast majority of the very rare cases of loss or discovery of so-called “orphan sources” in Germany, radioactive sources of low activity are concerned. Loss and discovery of radioactive materials are regularly recorded and assessed in reports of the BfS.

The working lives of the radioactive sources used are very different, in particular due to the strongly varying half-lives of the radionuclides used and the operating conditions. In most cases, the devices operated on the basis of a licence for handling are returned to the equipment manufacturer by the operator after end of use together with the source remaining in the device. The manufacturer may check further use of the sources or returns them to the source manufacturer who may reuse parts of them. The sources that cannot be reused are delivered to the *Land* collecting facilities where they are stored until delivery to a facility for disposal.

Shipment within the EU is not subject to licensing requirements. Transboundary movement within the EU is regulated by Council Regulation No. 1493/93/EURATOM [1F-34]. For sealed radioactive sources, prior notice of the competent authority based on a declaration of the addressee is essential (in Germany: the Federal Office of Economics and Export Control (BAFA)). The competent authority of the country of destination must also be notified of the completion of the shipment. As far as a transboundary movement is subject to legal requirements for licensing or notification, e.g. for re-entry of a radioactive source from a non-EU country, the competent authority according to § 22 AtG is the BAFA.

Main developments in Germany since the Fifth Review Meeting

On 16 June 2017, the Act on the Reorganisation of Responsibility in Nuclear Waste Management [1A-31] entered into force. The Act implements the recommendations of the Commission to Review the Financing for the Phase-out of Nuclear Energy (KFK) and reorganises the responsibility for nuclear waste management. It brings together the responsibility for financing and action in all areas. In the future, the Federation will be responsible for the implementation and financing of storage and disposal. The operators transfer the financial means into a public-law fund established with entry into force of the Act in the legal form of a foundation, which provides the Federation or a third party to be established by the Federation with the funds for the waste management steps to be carried out. In return, the spent fuel and radioactive waste, as well as the storage facilities defined in the Act, will be transferred to the Federation. In addition to the operator, the so-called controlling companies are also liable for the payment obligations remaining with the operator for the decommissioning of nuclear power plants and radioactive waste management. Thus, the Act secures the financing of decommissioning, dismantling and waste management in the long term without passing on the costs incurred for this purpose unilaterally to society and without jeopardising the economic situation of the operators.

The operators of the nuclear power plants will continue to be responsible for the entire management and financing of decommissioning, dismantling and proper packaging of the radioactive waste. The responsibility for action in the fields of storage and disposal lies with the Federation. The related tasks are performed by the publicly owned companies and financed by the fund. The financial resources of around 24 billion euros were provided to the Federation by the operators and transferred to a fund, organised as a foundation under public law, in the beginning of July 2017. The fund collects, deposits and disburses the funds. The spent fuel and radioactive waste, as well as the storage facilities defined in the Act, will be transferred to the Federation.

On 16 May 2017, the Act Amending the StandAG [1A-7b] largely entered into force. The Act is based on the recommendations of the Commission on the Storage of High-Level Radioactive Waste.

Several amendments have been made to the version of the Repository Site Selection Act of 27 July 2013. In particular, detailed regulations were introduced for comprehensive and transparent participation procedures in order to fully involve the public in the selection procedure before taking decisions. Based on the Commission's recommendations on the performance of the site selection procedure, the phases of the procedure were specified and adapted, in particular to take account of the existing need for comprehensive and early participation and to ensure effective performance of the respective phases. In addition, criteria were developed for site selection, taking into account the recommendations of the Commission, and a regulation was established for early safeguarding of areas potentially suitable for disposal against changes which could impair its suitability for disposal.

On 27 April 2017, the *Bundestag* passed the Act on the Reorganisation of the Law on the Protection against the Harmful Effects of Ionising Radiation [1A-29a]; on 12 May 2017, the *Bundesrat* approved the Act. This Act was drawn up against the background of Council Directive 2013/59/EURATOM [1F-24] laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation of 5 December 2013, which entered into force on 6 February 2014 and is to be transposed into national law in the member states by 6 February 2018.

Within the framework of this Act, which amends various acts, a new act regulating the protection against the harmful effects of ionising radiation (Radiation Protection Act – StrlSchG) [1A-29b] will be enacted, which will reorganise the German radiation protection system according to the distinction between existing, planned and emergency exposure situations as defined by Council Directive 2013/59/EURATOM. At the same time, the amendment will, among other things, result in the adaptation of numerous specifications according to the state of the art in science and technology, thus improving, for example, radiation emergency preparedness of the Federation and the *Länder.*

In addition, with this Act, the Act on the Precautionary Protection of the Population against Radiation Exposure (Precautionary Radiation Protection Act – StrVG) was repealed and other acts and ordinances amended.

With the entry into force of the Thirteenth Act Amending the Atomic Energy Act [1A-25] on 6 August 2011 as a result of the events in Japan, the authorisation for power operation expired for eight nuclear power plants. On 27 June 2015, the Grafenrheinfeld (KKG) nuclear power plant was permanently shut down.

Further provisions of Council Directive 2011/70/EURATOM [1F-36] on a Community framework for the responsible and safe management of spent fuel and radioactive waste were transposed into national law with the Fourteenth Act Amending the Atomic Energy Act of 20 November 2015.

A Introduction

A.1 Structure and content of the report

The Federal Government will continue to meet Germany´s existing international obligations, particularly with regard to the fulfilment of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. In submitting this report, Germany is demonstrating its compliance with the Joint Convention and how it ensures the safe operation of facilities for the management of spent fuel and radioactive waste, including the decommissioning of nuclear facilities. At the same time, there is also still a need for future action in order to continue maintaining the required high standards of safety and ensure disposal.

The report to the Joint Convention follows the guidelines regarding the form and structure of national reports. As such, it is divided into sections which address the individual Articles of the Joint Convention as prescribed in the guidelines. An introduction considering the historical and political development of nuclear power use is followed by a comment on each individual obligation. Statements made in the report tend to be of a generic nature, although plant-specific details are given wherever necessary in order to illustrate compliance with the requirements of the Convention.

In order to demonstrate compliance with the obligations, explanatory comments are given on the pertinent national laws, ordinances and standards, and descriptions are provided of the manner in which essential safety requirements are met. In the current national report, special emphasis is placed on describing the licensing procedure and state supervision, as well as the measures applied by the operators at their own responsibility for maintaining an appropriate standard of safety.

The annexes to the report contain a list of nuclear facilities currently in operation as defined by the Joint Convention with their safety-relevant design characteristics, a list of facilities in the process of decommissioning and dismantled facilities, plus a comprehensive list of the legal and administrative provisions, statutory regulations and guidelines in the field of nuclear power which are relevant for the safety of the facilities as defined by the Joint Convention and which are referred to in this report.

The sixth German national report does not merely include modifications of the previous reports but provides an integrated overall description. Any major amendments since the report for the Fifth Review Meeting in May 2015 are summarised at the beginning of the respective sections in an info box (Developments since the Fifth Review Meeting).

All information and data provided by the report apply as at the deadline of 31 March 2017 unless expressly specified otherwise.

The sixth German report under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was jointly revised and updated by organisations dealing with the safe disposal of spent fuel and radioactive waste in Germany. These are the nuclear regulatory authorities of the Federation and the *Länder*, supported by expert organisations, as well as the electric power utilities as important waste producers, involved by a representative of their joint most important service provider, the GNS Gesellschaft für Nuklear-Service mbH (GNS). The report was approved by the Federal Government at its Cabinet meeting on 30 August 2017.

According to the national regulations of the Federal Republic of Germany, which are in line with the international requirements, the residual materials generated from former uranium ore mining are not counted among the radioactive waste, which is why these activities are – as in the National Reports since the Second Review Meeting – presented in a separately annexed report describing the status of the ecological restoration as at 31 March 2017.

A.2 Historical development and current status of utilisation of nuclear energy

Research and development

In the Federal Republic of Germany, research and development in the field of the civil use of nuclear energy began in 1955 after the Federal Republic of Germany had officially renounced the development and possession of nuclear weapons. The research and development programme at that time was based on intensive international cooperation and included the construction of several experimental and demonstration reactors, as well as the elaboration of concepts for a closed nuclear fuel cycle and for disposal of radioactive waste in deep geological formations.

In 1955, the Federal Government established the Federal Ministry for Nuclear Affairs and Germany became a founder member of the European Atomic Energy Community (EURATOM) and the Nuclear Energy Agency (NEA) of the OECD. German and US power plant manufacturers jointly began to develop commercial nuclear power plants for the German market: Siemens and Westinghouse developed pressurised water reactors (PWRs), AEG and General Electric boiling water reactors (BWRs).

In subsequent years, the following nuclear research centres were founded in West Germany:

1956	in Karlsruhe (Kernforschungszentrum Karlsruhe, KfK, now Karlsruhe Institute of Technology (KIT))
	in Jülich (Kernforschungsanlage Jülich, KFA, now Forschungszentrum Jülich GmbH (FZJ); the Nuklearservice division of the FZJ was transferred to the JEN Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH)
	in Geesthacht (Gesellschaft für Kernenergieverwertung in Schiffbau und Schifffahrt, GKSS, now Helmholtz-Zentrum Geesthacht, HZG)
1959	in Berlin (Hahn-Meitner-Institut für Kernforschung, HMI, now Helmholtz-Zentrum Berlin, HZB)
	in Hamburg (Deutsches Elektronen-Synchrotron, DESY)
1964	in Neuherberg near Munich (Gesellschaft für Strahlenforschung, GSF, now Helmholtz Zentrum München – German Research Center for Environmental Health, HZM)
1969	in Darmstadt (Gesellschaft für Schwerionenforschung, GSI)

Many universities were equipped with research reactors. The Munich research reactor Garching (FRM) in Garching was the first to go critical on 31 October 1957, and the most recent operating licence was granted on 2 May 2003 for the Research Neutron Source Heinz Maier-Leibnitz of the Technical University of Munich (FRM II) at the same site. Operation was started in the year 2004.

In the former German Democratic Republic (GDR), the peaceful use of nuclear energy began with the development of a nuclear programme for nuclear research and nuclear technology in 1955. The offer of the USSR to the states within their sphere of influence to support the establishment of their own nuclear research institutions with the provision of research reactors and large-scale nuclear equipment was readily accepted by the former political leadership of the GDR. The establishment of the Central Institute for Nuclear Research (ZfK) in Rossendorf near Dresden took place in 1956; a research reactor supplied by the USSR went into operation here in 1957. In parallel, new chairs were set up at the institutions of higher education and universities in the fields of nuclear engineering and nuclear physics. In this way, a broad research and development base was created in the GDR for basic research in nuclear physics, radiochemistry and isotope production as well as for research work on the scientific and technical basis of the use of nuclear energy. At the turn of 1991/1992, the former facilities were taken over by the Rossendorf research centre FZR (now Helmholtz-Zentrum Dresden-Rossendorf (HZDR)) for the research tasks and by the Nuclear Engineering and Analytics Rossendorf Inc. (VKTA) for the dismantling of the nuclear facilities.

Development of nuclear reactors in the Federal Republic of Germany

In 1958, the first German nuclear power plant, the 16 MWe experimental nuclear power plant (VAK) in Kahl, was ordered from General Electric and AEG, which became operational in 1960.

Commercial power reactors with 250 to 350 MWe and 600 to 700 MWe respectively were ordered between 1965 and 1970. In 1966, the first commercial boiling water reactor was taken into operation in Gundremmingen with the KRB-A (250 MWe), and the first commercial pressurised water reactor 1968 in Obrigheim with the KWO (350 MWe). From 1970, larger power reactors (PWRs and BWRs) of the 1,300 MWe class were built. In 1975, the first reactor of this class went into operation in Biblis with the KWB-A (1,225 MWe), the last in 1989. All eight power reactors still in operation have a gross capacity between 1,344 and 1,485 MWe.

In the 1950s, the independent development of a series of experimental and demonstration reactors began in close cooperation between the nuclear research centres and the industry. Worth mentioning in this connection are the 15 MWe high temperature pebble bed reactor AVR (Arbeitsgemeinschaft Versuchsreaktor GmbH) at the former Kernforschungsanlage Jülich ordered in 1958, and the 57 MWe heavy-water PWR MZFR (multi-purpose research reactor) in the former Karlsruhe nuclear research centre ordered in 1961. Here, in the early 1960s, the development of a fast breeder reactor (FBR) began. This was later followed by the construction of a high-temperature reactor as a pebble-bed reactor based on thorium (THTR 300) in Hamm-Uentrop and a fast breeder reactor (SNR 300) in Kalkar as prototypes. The THTR was in operation between 1983 and 1989 and is in safe enclosure now; the spent fuel is stored in the Ahaus transport cask storage facility. Although the SNR 300 was completed, it was never loaded with fuel assemblies. The SNR 300 fuel that had been already produced was processed in France into mixed-oxide (MOX) fuel for light water reactors.

Construction of nuclear reactors in the former GDR

Since the GDR did not have its own development programmes for nuclear power plants, nuclear power plants should be imported from the USSR as turnkey facilities. The first commercial power reactor in the GDR – a 70 MWe pressurised water reactor of Soviet design – was built in Rheinsberg and commissioned in 1966. From 1973 to 1989, five pressurised water reactors – four of the VVER-440/230 type and one of the VVER-440/W-213 type – started operation in Greifswald.

With the accession of the GDR to the Federal Republic of Germany in accordance with Article 23 of the Basic Law (GG) (in the version applicable until 1990), the Atomic Energy Act (AtG) [1A-3] applies for the territory of the former GDR. In the course of German reunification, the five reactors in Greifswald were shut down in 1989/1990 and the reactor in Rheinsberg in 1990. They are now being dismantled. Work already under way for the construction of three additional VVER-440 reactors in Greifswald and two VVER-1000 reactors at the first construction stage in Stendal was terminated.

Termination of the commercial production of electricity from nuclear energy

In 1998, the Federal Government decided to phase out the use of nuclear energy for commercial production of electricity in a controlled manner. This decision applies in principle until today. In 2000, a consensus was reached with the power plant operators and fixed by contract.

The Act on the structured phase-out of the utilisation of nuclear energy for the commercial generation of electricity of 22 April 2002 [1A-2] established new boundary conditions for the use of nuclear energy in Germany. The phase-out in a controlled manner was formulated as one of the purposes of the AtG [1A-3]. The starting point for a gradual phase-out of the operation of the nuclear power plants was an average operating lifetime of 32 years. Under these boundary conditions, the operator decided to decommission the nuclear power plant in Stade (KKS) in 2003. In 2005, the nuclear power plant in Obrigheim KWO was shut down for decommissioning (see Table L-14).

In 2010, the Federal Government decided to extend the lifetimes of the nuclear power plants still in operation, but the events in Japan in March 2011 led to a reassessment of the risks associated with the use of nuclear energy. As a consequence, the authorisation for power operation expired for the eight plants Biblis Unit A, Neckarwestheim I, Biblis Unit B, Brunsbüttel, Isar 1, Unterweser, Philippsburg 1 and Krümmel with the Thirteenth Act Amending the Atomic Energy Act [1A-25] of 6 August 2011. On 31 December 2015 the Grafenrheinfeld nuclear power plant was also to cease operation but the then operator E.ON Kernkraft GmbH (now PreussenElektra GmbH) decided to already shut down the plant permanently on 27 June 2015. For the Gundremmingen nuclear power plant, Unit B, authorisation for power operation expires on 31 December 2017. For the seven nuclear power plants still in operation, the authorisation for power operation will expire successively between the end of 2015 and the end of 2022, or earlier if reaching the electricity volumes listed in Table A-1.

Table A-1: Electricity volumes and expiry of authorisation for power operation according to the Thirteenth Act Amending the Atomic Energy Act [1A-25]

Plant	Electricity volumes as from 1 January 2000 [TWh net]	Start of commercial power operation	Expiry of authorisation for power operation
Obrigheim	8.70	01.04.1969	-
Stade	23.18	19.05.1972	-
Biblis Block A	62.00	26.02.1975	06.08.2011
Neckarwestheim I	57.35	01.12.1976	06.08.2011
Biblis Block B	81.46	31.01.1977	06.08.2011
Brunsbüttel	47.67	09.02.1977	06.08.2011
Isar 1	78.35	21.03.1979	06.08.2011
Unterweser	117.98	06.09.1979	06.08.2011
Philippsburg 1	87.14	26.03.1980	06.08.2011
Grafenrheinfeld	150.03	17.06.1982	31.12.2015
Krümmel	158.22	28.03.1984	06.08.2011
Gundremmingen B	160.92	19.07.1984	31.12.2017
Philippsburg 2	198.61	18.04.1985	31.12.2019
Grohnde	200.90	01.02.1985	31.12.2021
Gundremmingen C	168.35	18.01.1985	31.12.2021
Brokdorf	217.88	22.12.1986	31.12.2021
Isar 2	231.21	09.04.1988	31.12.2022
Emsland	230.07	20.06.1988	31.12.2022
Neckarwestheim II	236.04	15.04.1989	31.12.2022
Subtotal	**2,516.06**		
Mülheim-Kärlich	107.25	01.08.1987	-
Total	**2,623.31**		

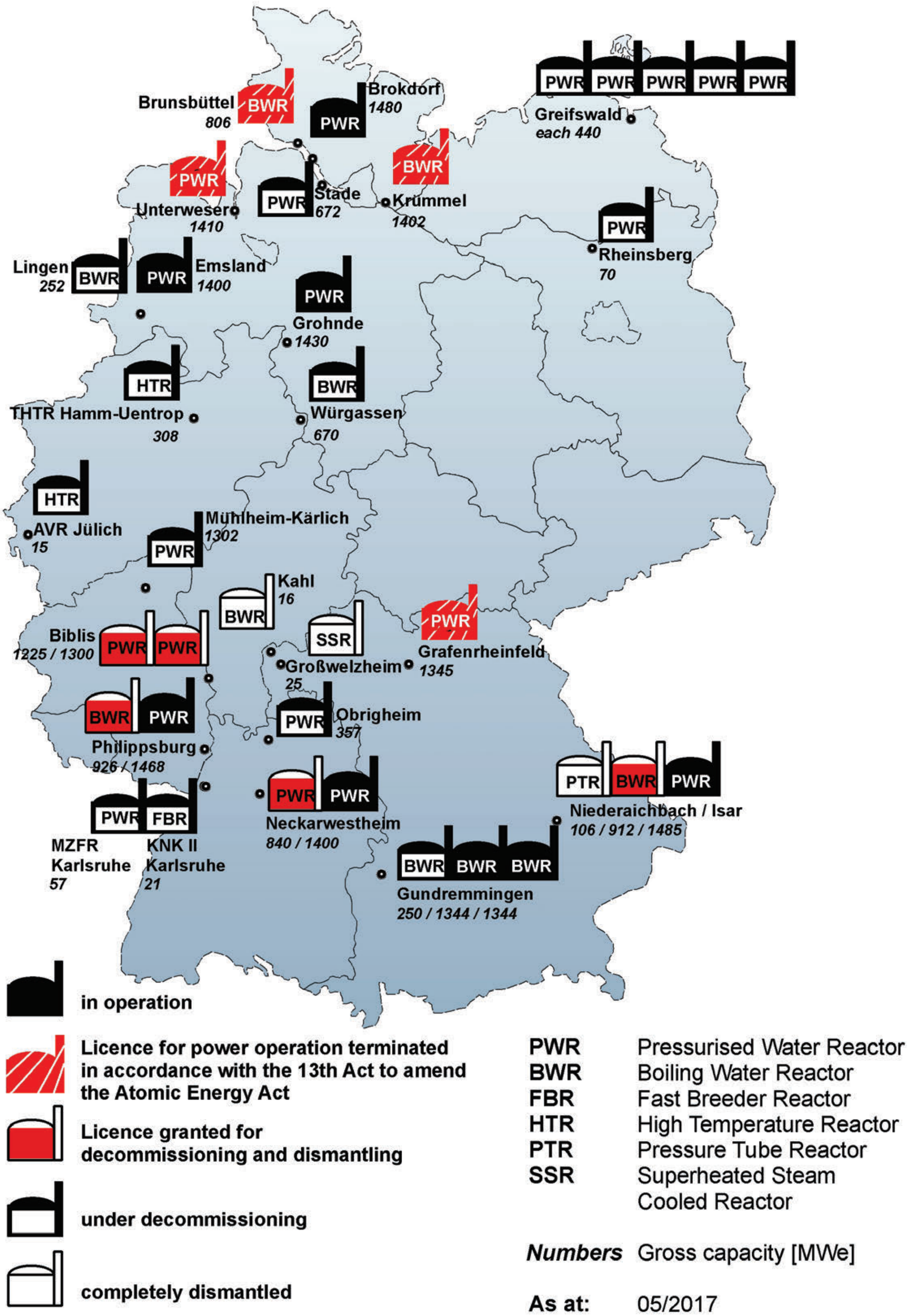
Note: The electricity volume of 107.25 TWh for the Mülheim-Kärlich nuclear power plant can be transferred to the nuclear power plants Emsland, Neckarwestheim II, Isar 2, Brokdorf, Gundremmingen B and C.

For the nuclear power plants shut down in 2011, applications for decommissioning and dismantling have meanwhile been filed (see Table L-20 in Annex L-(c)) with the decommissioning option of immediate dismantling. Until granting of the decommissioning licence, the plants are operated on the basis of the existing operating licences. Biblis Unit A has been free from nuclear fuel since November 2016, Philippsburg 1 since December 2016. With Isar 1, the first plant shut down in 2011 was granted the first licence for decommissioning and dismantling on 17 January 2017. The Neckarwestheim I nuclear power plant followed on 3 February 2017, Biblis Unit A and Biblis Unit B on 30 March 2017 and Philippsburg 1 on 7 April 2017.

With the successive phase-out of the use of nuclear energy, the share of nuclear energy in the gross electricity production in Germany decreased from 22.2 % in 2010 to 13.1 % in 2016.

The geographical locations of the German nuclear power plants in operation and under decommissioning are shown in Figure A-1.

Figure A-1: Nuclear power plants, experimental and demonstration reactors in Germany



Facilities of the nuclear fuel cycle

With the commercial use of nuclear energy in Germany, facilities of the nuclear industry emerged in the western *Länder* in addition to the power reactors as well as facilities for treatment or storage of the resulting radioactive waste.

Facilities for the fabrication of uranium, high temperature reactor (HTR) and mixed-oxide (MOX) fuel were operated at the Hanau site. These have meanwhile been decommissioned and dismantled; with achievement of the radiological remediation target, radiological groundwater remediation at the site could be terminated.

One uranium enrichment plant at Gronau and one fuel fabrication plant at Lingen are in operation.

In Karlsruhe, the Karlsruhe reprocessing plant (WAK) was built under the leadership of the local research centre and put into operation in 1971. As a pilot plant, it had the task to gain experience for planning, construction and operation of a larger German reprocessing plant. In addition, methods for reprocessing and waste treatment were to be further developed. The technical scale was chosen such that direct application of operating experience to a large industrial plant was possible.

In 1990, the WAK was taken out of operation and is currently being dismantled. The approximately 60 m³ of high level fission product solutions from operation were vitrified at the Karlsruhe Vitrification Plant (VEK) in the period from September 2009 to June 2010. Five casks of the CASTOR® HAW 20/28 CG type filled with the 140 canisters produced were transferred to the Zwischenlager Nord (ZLN) of the Entsorgungswerk für Nuklearanlagen GmbH (EWN) near Greifswald.

In the 1970s, the German electric power utilities planned the so-called Nukleares Entsorgungszentrum (NEZ), a nuclear waste management centre consisting of a reprocessing plant, fuel fabrication plants for uranium and MOX fuel, waste management facilities for all types of waste and a repository for all this waste. The NEZ was to be constructed at the Gorleben site in Lower Saxony (see Chapter D.3.3 for details). With the exception of the repository project, plans for the centre were later shelved in 1979, whereupon the utilities turned instead to plans for a scaled-down project which would be confined to the reprocessing, the fabrication of MOX fuel and the treatment of radioactive waste at Wackersdorf in Bavaria. In 1989, this project was also abandoned and the ongoing licensing procedure was cancelled. From then onwards, the utilities exclusively turned their attention instead to reprocessing in other European countries.

Although in the former GDR there were large uranium deposits in the Erzgebirge, no nuclear facilities of the nuclear fuel cycle have been constructed or operated on an industrial scale. The fuel assemblies for reactors in Rheinsberg and Greifswald were fabricated in the USSR and delivered, spent fuel was taken back. In 1968, the GDR abandoned breeder research due to safety concerns. In the same year, planning began for a plant for “refabrication of fuel assemblies", called "Komplex 04" for reprocessing of spent fuel for the fast experimental reactor BOR-60 in the USSR. In 1977, the plant went into operation in the USSR. In 1975, the construction of a plant for industrial fabrication of fuel assemblies for the USSR, called “Komplex 05”, was commissioned by the GDR Council of Ministers, but execution was rejected in 1979 by the USSR and then terminated by the GDR [ABE 00], [LIE 00].

Spent fuel and radioactive waste management

First considerations

A memorandum of the German Atomic Commission, an advisory body to the former Ministry for Atomic Issues, of 9 December 1957 already pointed out the need for comprehensive development work in the field of radioactive waste management. Since 1976, the AtG [1A-3] contains the requirement that radioactive waste is to be disposed of in a controlled manner by the introduction of § 9a. Furthermore, the Principles Relating to the Provisions to be Made for the Handling and Disposal of Spent Fuel of Nuclear Power Plants, which were amended by decision of the heads of government of the Federation and the *Länder* on 28 September 1979 (printed paper of the German *Bundestag* 11/1632) stipulated as a prerequisite for licences to commission and operate the nuclear power plants that the guaranteed safekeeping of the spent fuel had to be demonstrated six years in advance.

In the GDR, the office for radioactive residues and wastes (*Zentrale für radioaktive Rückstände und Abfälle*) was established in Lohmen, municipality of Sebnitz with effect from 1 April 1959 with the tasks of registration, transportation, treatment and concentration as well as the emplacement of radioactive residues and wastes [DDR 59]. For centralised registration of radioactive waste, appropriate guidelines were adopted [SZS 65]. The decision made about 10 years later to establish and operate a central repository for low- and intermediate-level radioactive waste led to the closure of the Lohmen site; from 1971, the radioactive waste temporarily stored here were transferred to the Bartensleben salt mine in Morsleben (the later Morsleben repository for radioactive waste, ERAM). In 1983, the Lohmen site was finally closed down.

The sites of today's radioactive waste management facilities – as far as they have not been constructed at the sites of nuclear power plants (see Figure A-1) – are shown in Figure D-1.

Reprocessing of spent fuel in other European countries

Until the end of June 2005, spent fuel was allowed to be transported to France and the United Kingdom for reprocessing. With the German phase-out decision and the amendment to the Atomic Energy Act in 2002 [1A-2], the transfer of spent fuel from power reactors for the purpose of reprocessing has been prohibited with effect from 1 July 2005 and was replaced by the objective of direct disposal of spent fuel.

The plutonium separated during reprocessing was used for the fabrication of mixed-oxide (MOX) fuel and fully recycled in German light water reactors. Thus, the recycling of the entire separated plutonium has been completed by reuse.

Storage of spent fuel

In the 1980s, two central storage facilities were built in Ahaus and Gorleben for the storage of spent fuel but also for radioactive waste from reprocessing. The storage licence according to § 6 AtG was granted for Gorleben in 1995, that for Ahaus in 1997. Another storage facility for the fuel of the nuclear power plants Greifswald and Rheinsberg was built near Rubenow and put into operation in 1999. For the fuel spheres of the AVR, a cask storage facility was built in the FZJ. The storage licence was granted on 17 June 1993 and expired on 30 June 2013. The storage of the fuel spheres is currently based on an order issued by the competent supervisory authority of the *Land* of North Rhine-Westphalia.

Since according to § 9a AtG delivery of spent fuel to facilities for reprocessing has been prohibited with effect from 1 July 2005, the operators of nuclear power plants are required to furnish proof that adequate waste management provisions exist for the spent fuel and for the radioactive waste to be taken back from abroad by the provision of adequate storage capacities with the objective of direct disposal. This requirement has been met with the construction and operation of on-site storage facilities for spent fuel storage until delivery to a facility of the Federation for disposal.

On-site storage facilities for spent fuel in transport and storage casks were built and put into operation at twelve nuclear power plant sites (see Table L-4). One exception is the wet storage facility at the KWO, whose spent fuel assemblies are delivered to the storage facility of the

Neckarwestheim nuclear power plant (GKN). A corresponding modification licence for the on-site storage facility at Neckarwestheim covering the storage of KWO fuel assemblies was granted on 9 August 2016. The licence for the transport of the casks by ship via the river Neckar was granted on 16 May 2017. It is expected that by the end of the first quarter of 2018, all fuel assemblies will have been removed from Obrigheim. The storage licence for the on-site storage facility at Brunsbüttel site granted on 28 November 2003 has been revoked with the judgement of the Schleswig-Holstein Higher Administrative Court and its confirmation by the Federal Administrative Court on 8 January 2015. The storage of the fuel assemblies is tolerated for the duration of a licensing procedure, but not later than January 2018, on the basis of a nuclear supervisory order issued by the competent licensing authority. A new licence for the on-site storage facility was applied for on 16 November 2015.

Conditioning of spent fuel

The licensing procedure for the Gorleben pilot conditioning plant (PKA), which is designed for the conditioning of spent fuel for direct disposal, was concluded in December 2000 with the granting of the third partial construction licence. According to an ancillary provision in the licensing decision, its operation is currently limited to the possibly required repair of defective transport and storage casks for spent fuel and HLW glass canisters.

Conditioning and storage of radioactive waste

By means of conditioning of the radioactive waste, intermediate or final products shall be produced which fulfil the requirements on safe handling, storage and transport also for the period of extended storage. The radioactive waste is stored until it is delivered to a facility of the Federation for disposal. The waste is to be conditioned without any delay. The conditioning of the raw waste of the nuclear facilities such as to meet the waste acceptance requirements for disposal is the responsibility of waste producers.

Conditioning comprises the treatment and/or packaging of radioactive waste. Depending on the composition and condition of the radioactive waste, methods and equipment proven to be appropriate over many years are used. Some conditioning procedures are performed in mobile or stationary facilities at the power plant site, for other procedures, the raw waste is delivered to external stationary facilities and the conditioned waste produced returned.

Disposal

In the Federal Republic of Germany, disposal began with the rededication of the former potash and rock salt mine **Asse II** in 1965. Between 1967 and the end of 1978, about 47,000 m³ of low and intermediate level radioactive waste were emplaced here in different types of packages. Since 1988, there has been a continuous inflow of groundwater from the overburden into the mine. At the same time, the stability of the mine started to deteriorate successively due to the pressure of the overlying overburden and the decreasing load-carrying capacity of the mine workings.

According to § 57b AtG [1A-3], the Asse II mine must therefore be closed immediately. The Federal Office for Radiation Protection (BfS), as the then responsible operator of the facility, applied for the initiation of a plan approval procedure under nuclear law at the Lower Saxony Ministry for the Environment, Energy and Climate Protection (NMU) in written form on 11 February 2009.

After having examined three procedural options, on 15 January 2010, the BfS announced that, taking the present state of knowledge into account, the complete retrieval of all waste would be the best closure option (see Chapter D.3.4). In order to gain time for the implementation of retrieval, comprehensive stabilisation measures are being carried out in the mine workings.

The concept for the complete retrieval of the radioactive waste provides for recovering all the waste, to transport it above ground in transport casks and to condition it there. For this purpose, a sufficiently large storage facility with conditioning plant needs to be planned and built. As a planning basis, the operator (BGE) assumes that all waste and an additional amount of contaminated crushed salt have to be conditioned and stored. The BfS had proposed criteria [BfS 14] on the basis of which a selection and evaluation of potential sites is possible. First of all, according to a BfS proposal, sites shall be investigated that can be connected to the premises of the Asse II.

For the **Konrad mine**, a former iron ore mine, the plan approval decision regarding the construction and operation of a repository for radioactive waste with negligible heat generation was issued on 22 May 2002. The complaints raised against the plan approval decision were rejected so that since 2007, there is thus a definitive plan approval decision. With letter dated 30 May 2007, the BfS was commissioned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) with the conversion of the Konrad mine. After having adapted the planning to the advanced state of the rules and regulations and other provisions of the Federation, conversion work was started. The company Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH (DBE) was commissioned with the conversion of the Konrad mine into a repository. The new date given by the DBE in the draft framework schedule for commissioning of the Konrad mine repository is the year 2022.

The **Gorleben site** was initially agreed upon in 1977 for the establishment of a nuclear waste management centre for reprocessing and fuel fabrication as well as for the storage, treatment and disposal of radioactive waste. Later, the planning was limited to the use as a potential repository site. Starting from 1979, the Gorleben salt dome had been explored geoscientifically for its suitability as a host rock for a repository. In 1986, underground exploration of the salt dome began with the sinking of the shafts. The exploratory work was interrupted between October 2000 and September 2010 in the context of the decision to phase out the use of nuclear energy on the basis of a moratorium agreed between the Federal Government and the power plant operators. After clarification of conceptual and safety-related issues by the BfS, the exploration was resumed in October 2010, but then again discontinued in November 2012 in the context of the beginning discussions on the fundamental reorganisation regarding the issue of disposal of heat-generating radioactive waste. With the entry into force of the Repository Site Selection Act on 27 July 2013, the mining exploration was officially ended. A preliminary safety analysis for a potential repository at the Gorleben site was concluded. For this analysis, it was decided not to conduct suitability forecast. The mine will be kept open in a reduced operating mode, subject to the compliance with all legal requirements and taking of the necessary maintenance measures until decision on a site, unless it will be excluded from the site selection procedure according to criteria laid down by law.

In the former GDR, the search for a central repository for low and intermediate level radioactive waste began in the late 1960s. The choice fell on the salt mine Bartensleben in Morsleben. After investigations and first trial emplacements of radioactive waste from the Lohmen storage facility, a temporary licence was initially granted for the **Morsleben repository** for radioactive waste (ERAM) for five years in 1981. This was followed by a permanent operating licence of unlimited validity granted on 22 April 1986. After German reunification, the ERAM was operated by the BfS and used for the emplacement of low and intermediate level radioactive waste from all over Germany until September 1998. In the period from 1971 to 1998, 36,753 m³ of radioactive waste and 6,621 disused sealed radioactive sources were disposed of in this facility with a total activity of around 10^{14} Bq. In response to a technical re-evaluation, the BfS irrevocably waived further emplacement. Since the end of emplacement operations, the plan approval procedure for backfilling and closure of the ERAM has been pursued which the BfS had already applied for on 9 May 1993.

Reorganisation regarding the issue of disposal of heat-generating radioactive waste

On 27 July 2013, the Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste and for the Amendment of Other Laws (Repository Site Selection Act – StandAG) [1A-7a] entered into force. This Act regulates the site selection procedure for the determination of a repository site for heat-generating radioactive waste.

On the basis of the StandAG, the Commission on Storage of High-Level Radioactive Waste examined and assessed the relevant fundamental issues with regard to radioactive waste management. Furthermore, the Commission has evaluated the StandAG and made recommendations for its further development. The *Bundestag* and the *Bundesrat* have reviewed these recommendations and considered them in the Act on the Reorganisation of the Organisational Structure in the Field of Disposal [1A-30] as well as in the Act Amending the Repository Site Selection Act [1A-7b] (see Chapter E.2.2 for details on the Act on the Reorganisation of the Organisational Structure in the Field of Disposal as well as on the Repository Site Selection Act).

The Federal Office for the Safety of Nuclear Waste Management (BfE) was established on 1 September 2014 as the new licensing and supervisory authority for radioactive waste management, which in the future will also monitor the implementation of the site selection procedure. In July 2016, the BGE was founded as the project implementer for planning, construction, operation and decommissioning of repositories, which is organised under private law but remains in federal ownership. On 25 April 2017 the operator tasks were transferred to the BGE.

With the amendment of the Repository Site Selection Act, the criteria and decision bases for the site selection were defined. The selection procedure is divided into three phases (see Chapter H.3.2 for details on repositories for heat-generating radioactive waste).

According to the Repository Site Selection Act, the decision on a site shall be taken by 2031. The decision on a site will be followed by the licensing procedure according to § 9b(1a) AtG [1A-3].

Tailings from uranium mining

In 1946, a Soviet owned stock company began mining uranium ore on the territory that was later to become the GDR, and from 1954 these operations were continued by the Soviet-German Wismut joint-stock company. The mining of uranium ore was discontinued at the end of 1990 following German reunification. Uranium ore mining has left considerable environmental damage which since then has been remediated by the federally-owned company Wismut GmbH. The residues left over from the former uranium ore mining do not count as radioactive waste but, due to the great interest in this issue, details on the related activities are given in a report attached separately.

A.3 Overview

Table A-2 below was added according to a decision of the Second Review Meeting and provides an overview of the situation regarding spent fuel and radioactive waste management in Germany. The Morsleben repository for radioactive waste (ERAM) is regarded to be a completed waste management path.

Table A-2: Spent fuel and radioactive waste management in Germany

Waste management task	Long-term strategy	Financing	Current practice/ facilities	Planned facilities
Spent fuel	Spent fuel from power reactors: storage in casks, possible subsequent conditioning and direct disposal in deep geological formations.	Payment of a basic amount and an optional risk premium by the electric power utilities into a public-law fund for the future costs of storage, waste conditioning as well as for construction, operation and closure of a repository (polluter-pays principle). The availability of the funds is secured by the State. The Federation is responsible for financing the management of spent fuel from the nuclear power plants in the territory of the former GDR.	Three central dry storage facilities, AVR cask storage facility, 12 dry storage facilities at the nuclear power plant sites, one wet storage facility (Obrigheim).	Facility for disposal planned; site selection procedure according to the Repository Site Selection Act (StandAG).
	Spent fuel from research reactors: storage in casks, possible subsequent conditioning and direct disposal in deep geological formations; in exceptional cases return to the country of origin.	Financing from public funds in the case of publicly-owned facilities.	On-site storage, or in the Ahaus transport cask storage facility or ZLN storage facility.	Facility for disposal planned; site selection procedure according to the Repository Site Selection Act (StandAG).
Radioactive waste from the nuclear fuel cycle and the operation of the nuclear power plants	Storage at the site of origin or centrally with the objective of disposal in deep geological formations.	Annual reimbursement of costs incurred by the Federation and corresponding cost allocations on the basis of the polluter-pays principle. Financing from public funds in the case of publicly-owned facilities (polluter-pays principle).	Conditioning and storage (at the site of origin or centrally).	Waste with negligible heat generation: Konrad repository licensed; in the process of conversion; start of operation in 2022. Heat-generating waste: facility for disposal planned; site selection procedure according to the Repository Site Selection Act (StandAG).
		For waste from the nuclear power plants of the electric power utilities: payment of a basic amount and an optional risk premium by the electric power utilities into a public-law fund for the future costs of storage as well as for construction, operation and closure of a repository (polluter-pays principle). For heat-generating waste: see spent fuel (polluter-pays principle).	Conditioning and storage (at the site of origin or centrally).	Waste with negligible heat generation: Konrad repository licensed; in the process of conversion; start of operation in 2022. Heat-generating waste: facility for disposal planned; site selection procedure according to the Repository Site Selection Act (StandAG).

Waste management task	Long-term strategy	Financing	Current practice/ facilities	Planned facilities
Other radioactive waste	Storage at central locations with the objective of disposal in deep geological formations.	Waste producers pay fees to the *Land* collecting facilities (polluter-pays principle); *Land* collecting facilities pay disposal cost portion to the Federation.	Conditioning and storage (*Land* collecting facilities).	Konrad repository licensed; in the process of conversion; start of operation in 2022.
	Retrieval of the waste from the Asse II mine.	Financing by the Federation.	Fact finding and planning of retrieval, conditioning and storage as well as stabilisation of the mine.	Taking into account for the site selection procedure according to the Repository Site Selection Act (StandAG).
Decommissioning of nuclear facilities	Dismantling of the facilities and release of buildings and soil areas from the scope of the Atomic Energy Act (AtG).	Formation of provisions in the case of facilities of the electric power utilities and of the nuclear fuel cycle, financing from public funds in the case of publicly-owned facilities (polluter-pays principle).	Mainly immediate dismantling.	If required, storage capacities for waste from decommissioning.
Disused sealed radioactive sources	Return to the manufacturer or shipper, or delivery as radioactive waste to a *Land* collecting facility with the objective of disposal in deep geological formations.	Waste producers pay fees to the *Land* collecting facilities (polluter-pays principle); *Land* collecting facilities pay disposal cost portion to the Federation.	Repackaging by the manufacturer or conditioning and storage as radioactive waste (*Land* collecting facilities).	Konrad repository licensed; in the process of conversion; start of operation in 2022.

B Policies and practices

This section deals with the obligations under Article 32(1) of the Convention.

> ***Article 32(1): Reporting***
>
> *(1) In accordance with the provisions of Article 30, each Contracting Party shall submit a national report to each review meeting of Contracting Parties. This report shall address the measures taken to implement each of the obligations of the Convention. For each Contracting Party the report shall also address its*
>
> *i) spent fuel management policy;*
>
> *ii) spent fuel management practices;*
>
> *iii) radioactive waste management policy;*
>
> *iv) radioactive waste management practices;*
>
> *v) criteria used to define and categorise radioactive waste.*

B.1 Reporting

B.1.1 Spent fuel management policy

Since the 1990s, Germany's objective regarding the management of spent fuel has changed. Until 1994, the Atomic Energy Act (AtG) [1A-3] included the requirement of reusing the fissile material in the spent fuel. This requirement changed in 1994, and the operators of nuclear power plants then had the option of either reuse by means of reprocessing, or else of direct disposal.

Since 1 July 2005, delivery of spent fuel from commercial electricity production for the purposes of reprocessing has been prohibited in accordance with an amendment of the Atomic Energy Act to this effect of 22 April 2002 [1A-2]. The last spent fuel to be delivered for reprocessing was dispatched from the Stade nuclear power plant (KKS) in May 2005. Now, only the direct disposal of the spent fuel that exists and will be generated in future in Germany as radioactive waste is permissible.

For the spent fuel which had been delivered for reprocessing, the proof of reuse of the plutonium separated during reprocessing must be kept. This is to ensure that throughout the remaining residual operating lives of the nuclear power plants, all separated plutonium will be processed in the fabrication of mixed-oxide (MOX) fuel and thus be reused.

As there is as yet no repository available for the spent fuel, it will generally be stored at the sites where it was generated until a repository is commissioned; corresponding storage capacities exist as needed.

With the Act Amending the Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste and for the Amendment of Other Laws [1A-7b], the corresponding decision of the Commission on the Storage of High-Level Radioactive Waste on an export ban for spent fuel from reactors which are not used for commercial electricity generation has been implemented. After the amendment to the AtG according to the Act Amending the StandAG, export of spent fuel from research reactors is only permitted for serious reasons of non-proliferation of nuclear fuel or for reasons of a sufficient supply of fuel elements for medical and other top level research purposes. An exception to this is the shipment of such fuel assemblies with the aim of producing waste packages that are suitable for disposal and that are to be disposed of in Germany. An export licence shall not be granted if the spent fuel is already stored in Germany pursuant to § 6 AtG.

B.1.2 Spent fuel management practices

The reprocessing of the spent nuclear fuel delivered to France and the United Kingdom has been completed. During the period since the last report, the operators of the nuclear power plants have provided proof of the safe reuse of all plutonium generated by means of its reuse as MOX fuel in reactors and of the safe storage of all uranium.

All other types of spent fuel remaining in Germany and those which will continue to be generated will be stored until their final transportation to a disposal facility.

B.1.3 Radioactive waste management policy

For the selection of a repository site for heat-generating radioactive waste, the StandAG [1A-7a] was passed, which entered into force on 27 July 2013.

Prior to the actual site selection procedure, the Commission on the Storage of High-Level Radioactive Waste examined and assessed the relevant fundamental issues for the selection procedure with regard to radioactive waste management. In addition, the Commission evaluated the StandAG and submitted proposals for its amendment. The *Bundestag* and the *Bundesrat* examined the recommendations of the Commission and considered them in the Act on the Reorganisation of the Organisational Structure in the Field of Disposal [1A-30] and in the Act Amending the StandAG [1A-7b], which largely entered into force on 16 May 2017 (see Chapter E.2.2 for details on the Act on the Reorganisation of the Organisational Structure in the Field of Disposal as well as on the Repository Site Selection Act).

The objective of the StandAG is to find a site for a facility for the disposal of heat-generating radioactive waste which ensures the best possible safety for a period of one million years. The site selection procedure is to be concluded by 2031.

The legal requirement is that all steps of radioactive waste management are subject to the polluter-pays principle.

In accordance with this principle, the state obligates the producers of waste by law to ensure the controlled and safe management of radioactive waste generated during the operation and decommissioning of nuclear facilities (e.g. nuclear power plants and research centres). As such, they operate or order facilities in which the produced radioactive waste can be treated and stored until its disposal. This may take place either in decentralised or central facilities. The Waste Management Transfer Act regulates the transfer of financing and action obligations for the management of radioactive waste from operators of nuclear power plants. Accordingly, the Federation shall assume the financing obligation for the storage and disposal of radioactive waste at the time of payment pursuant to Annex 1 of the Waste Management Fund Act. The operators will transfer the storage facilities to a third party commissioned with storage management by the Federation free of charge. This will be on 1 January 2019 for storage facilities listed in Annex Table 1 (for spent fuel), and on 1 January 2020 for storage facilities listed in Annex Table 2 (for radioactive waste). In addition, the operators' obligation to act with regard to radioactive waste management passes to the Federation, starting with the transfer of the properly packaged waste to the publicly owned storage facility operator (see Chapter E.2.2 for details on the Act on the Reorganisation of Responsibility in Nuclear Waste Management).

The operators are responsible for the safe management of radioactive waste from reprocessing of German fuel assemblies in France and the United Kingdom, which Germany has undertaken to return, until it is transferred to a storage facility operated by the third party.

In so far as they are not stored by the producer, radioactive waste from research, industry and medicine must be delivered to *Land* collecting facilities that are to be provided by the *Länder*. The Federation is obliged to accept the waste from these storage facilities for disposal if it cannot be cleared after the radioactivity has decayed.

B.1.4 Radioactive waste management practices

Only solid (or solidified) radioactive waste will be accepted for disposal in deep geological formations; liquid and gaseous waste is excluded from acceptance. The controlled, safe disposal of radioactive waste therefore requires its conditioning.

Conditioning comprises several stages, depending on the quality and nature of the raw waste. After targeted collection or segregation (where necessary), the raw waste may first be pretreated and then be either processed into interim products or directly into packages suitable for storage or disposal.

Proven methods and reliable mobile or stationary installations already exist for the pretreatment and conditioning of radioactive waste. Mobile conditioning installations are the preferred choice for the treatment and packaging of operational waste from nuclear power plants. Stationary installations which are capable of conditioning various types of raw waste are used, among others, at the major research centres; there are also a number of other stationary conditioning installations which are operated on site by the respective waste producers.

In addition to German facilities, facilities in other European foreign countries are also utilised for waste management. Radioactive waste from the operation of nuclear facilities is delivered to Sweden for conditioning and subsequently returned to Germany.

Both central and decentralised storage facilities are available for the storage of radioactive waste with negligible heat generation from nuclear power plants and the nuclear industry. For waste from the use and handling of radioisotopes in research, industry and medicine (see reporting on Article 32 (1) iii), *Land* collecting facilities operated by the *Länder* are available for storage.

Heat-generating radioactive waste may be kept in storage in decentralised and central storage facilities. Waste from the reprocessing of spent fuel from German nuclear power plants is conditioned in France and the United Kingdom (e.g. vitrification of the high-level fission product solutions) and is then returned to Germany. Until the end of 2013, the Gorleben storage facility was provided for the storage of vitrified waste. As stipulated in the AtG, solidified fission product solutions from reprocessing abroad shall be taken back and stored in local storage facilities. According to § 6(5) AtG, the storage of nuclear fuel in nuclear facilities shall not exceed 40 years starting from the emplacement of the first cask.

B.1.5 Criteria used to define and categorise radioactive waste

Radioactive residues are produced during the operation of nuclear facilities and installations, as well as during the decommissioning or dismantling of such facilities. These residues are composed of reusable or recyclable materials and radioactive waste. Radioactive waste refers to materials which must be disposed of in a regulated manner (see definitions in § 2 AtG, regulations on the utilisation of residual radioactive material without detrimental effects and disposal of radioactive waste under § 9a AtG and § 29 of the Radiation Protection Ordinance (StrlSchV) [1A-8]). The mentioned activities may also generate material which is only marginally contaminated or activated.

Provided that such material is proven to comply with the clearance levels stated in Appendix III, Table 1 § 29 StrlSchV, it can be cleared and utilised, disposed of, possessed or transferred to third parties as non-radioactive material (see reporting on Article 24(2)(i) and (ii)). The non-exceedance of the clearance values ensures that the effective dose that may occur in case of reuse or disposal will only be in the range of 10 µSv/a for individuals of the public. There is a range of possibilities for reuse. Cleared tools and components can be used, e.g., in other nuclear power plants or also in conventional plants. Metals can be recycled by melting them down. Rubble can be used as raw material in road building, for backfilling of landfills or for the production of concrete. For electronic scrap, conventional recycling is applied, too.

In Germany, disposal in deep geological formations is intended for all types of radioactive waste. Accordingly, there is no need to differentiate between waste containing radionuclides with comparatively short half-lives and waste containing radionuclides with comparatively long half-lives. Thus, there are no measures or precautions required in order to separate the radioactive waste produced.

The proper registration and description of waste is an essential prerequisite of radioactive waste management. In accordance with the German approach to disposal, the definition and categorisation of radioactive waste (i.e. its classification) must comply with the requirements for safety assessment of an underground repository. In this respect, the effects of heat generation from radioactive waste on the design and evaluation of a repository system are particularly important, since the natural temperature conditions may be significantly altered by the waste emplaced. In order to meet the requirements concerning the registration and categorisation of radioactive waste from the point of view of disposal, it has been decided to refrain from using the terms LLW, ILW and HLW and to choose a new classification instead, which was made under particular consideration of aspects relevant for disposal and is based on the intention to dispose of all types of radioactive waste in deep geological formations. Accordingly, waste is initially subjected to a basic subdivision into

- heat-generating radioactive waste and
- radioactive waste with negligible heat generation.

This basic subdivision will also be made if the waste packages to be disposed of are kept in long-term surface storage prior to their transportation to a repository. Irrespective of this, the terms “low level waste" (LLW) or "intermediate level waste" (ILW) are used in exceptional cases for historical reasons. This is due to the fact that for the emplacement of radioactive waste in the Asse II mine and in the Morsleben repository for radioactive waste (ERAM) the waste was classified according to different criteria and the waste categories LLW and ILW were used during the operational phase.

Heat-generating radioactive waste is characterised by high activity concentrations and thus by a high decay heat. This waste places special demands on the design and operation of a repository in deep geological formations (use of special emplacement techniques, thermal design of the repository mine). It comprises, in particular, the vitrified fission product concentrate, hulls, structural components and feed sludge from the reprocessing of spent fuel, as well as the spent fuel itself if it is to be disposed of directly as radioactive waste.

Types of waste with significantly lower activity concentrations from the operation, decommissioning and dismantling of nuclear facilities and installations as well as from the application of radioisotopes are classified among the radioactive waste with negligible heat generation. These are e.g. disused plant components and defective components such as pumps or piping, ion exchange resins and air filters from waste water and exhaust air decontamination, contaminated tools, protective clothing, decontamination and cleaning agents, laboratory waste, sealed radioactive sources, sludges, suspensions, oils as well as contaminated and activated concrete structures and debris.

The term “radioactive waste with negligible heat generation” was quantified within the scope of the planning work for the Konrad repository. The objective of the related work was that the temperature conditions prevailing underground will only be influenced by the emplaced waste packages to a negligible extent. The realisation of this planning requirement eventually led to the quantitative stipulation that the increase in temperature at the wall of the disposal chamber caused by decay heat from the radionuclides contained in the waste packages must not exceed 3 K on average. This value is roughly equivalent to the temperature difference which occurs with a difference in depth of 100 m in the natural temperature environment, and is low compared to the change of temperature caused by ventilation. Compliance with the 3 Kelvin criterion was taken into account in connection with the safety-related analyses regarding the thermal influence on the host rock and is ensured by the limitation of the radionuclide-specific activity per waste package. These limits are laid down in the plan approval decision for the Konrad repository of 22 May 2002.

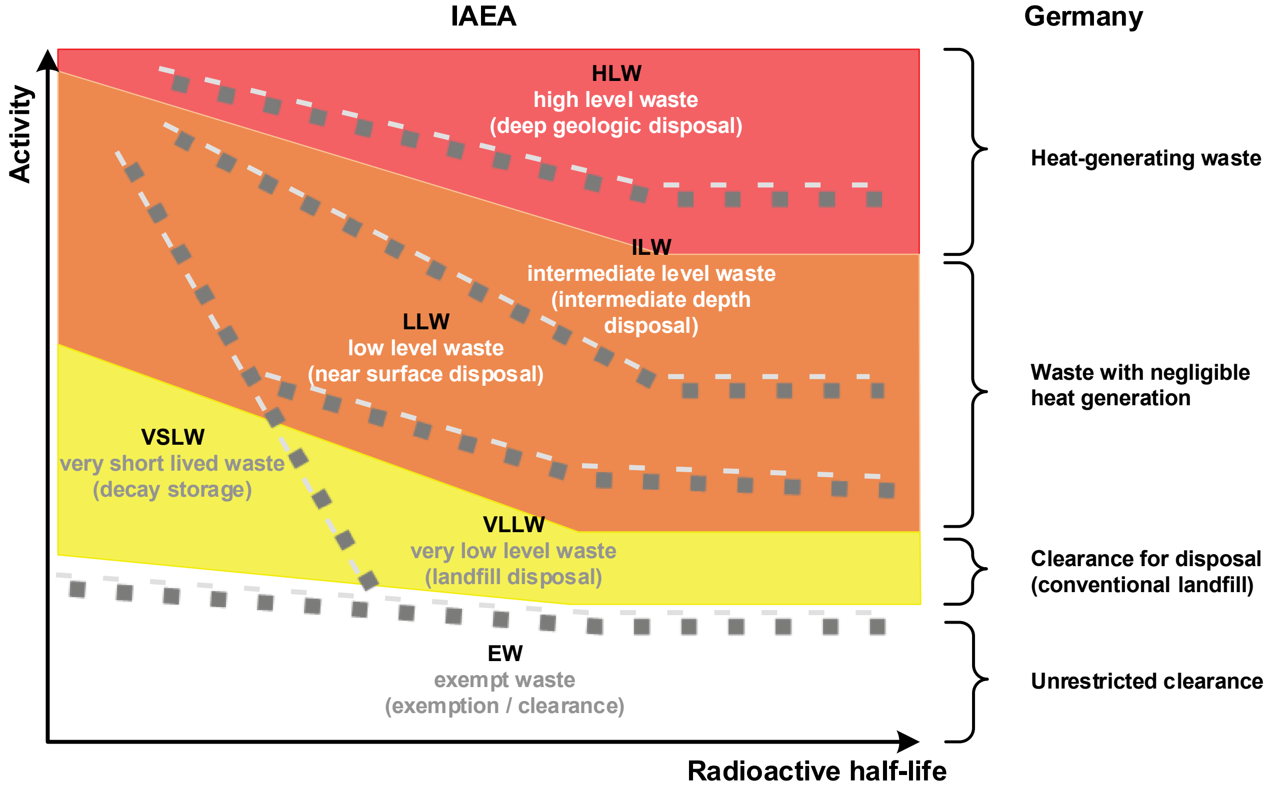
The waste categorisation according to heat-generating radioactive waste and radioactive waste with negligible heat generation has proven expedient. It is compatible with the International Atomic Energy Agency (IAEA) proposal for classification [IAEA 09a] which additionally permits a further subdivision into short-lived and long-lived waste, thus allowing waste to be assigned to near-surface disposal facilities and geological repositories.

In its General Safety Guide No. GSG-1 “Classification of Radioactive Waste” [IAEA 09a], the IAEA has recommended a classification scheme according to the following waste types:

- Exempt Waste (EW), no longer subject to regulatory control,
- Very Low Level Waste (VLLW), disposal in special landfill type facilities,
- Very Short Lived Waste (VSLW), decay storage,
- Low Level Waste (LLW), disposal in a near-surface facility,
- Intermediate Level Waste (ILW), disposal at intermediate depth, and
- High Level Waste (HLW), disposal in deep geological formations.

Figure B-1 includes a comparison of the IAEA waste classification and the German classification. The figure shows that the waste which according to the German classification is referred to as heat-generating radioactive waste (red area) yet reaches into the area of ILW and that certain types of waste referred to as VLLW according to the IAEA already exceed the current German clearance levels for management as conventional waste and therefore have to be disposed of in the Konrad repository. In general, it can be stated that the German classification blends in with the international classification with only slight deviations.

Figure B-1: Comparison of the IAEA waste classification and the German classification



Based on Directive 2011/70/EURATOM [1F-36] and the resulting preparation of a report on the National Programme (NaPro) for spent fuel and radioactive waste management [BMUB 15], the radioactive wastes are further classified according to the processing and examination conditions (see Chapter D.4.1).

C Scope of application

This section deals with the obligations under Article 3 of the Convention.

Article 3: Scope of application

(1) This Convention shall apply to the safety of spent fuel management when the spent fuel results from the operation of civilian nuclear reactors. Spent fuel held at reprocessing facilities as part of a reprocessing activity is not covered in the scope of this Convention unless the Contracting Party declares reprocessing to be part of spent fuel management.

(2) This Convention shall also apply to the safety of radioactive waste management when the radioactive waste results from civilian applications. However, this Convention shall not apply to waste that contains only naturally occurring radioactive materials and that does not originate from the nuclear fuel cycle, unless it constitutes a disused sealed source or it is declared as radioactive waste for the purposes of this Convention by the Contracting Party.

(3) This Convention shall not apply to the safety of management of spent fuel or radioactive waste within military or defence programmes, unless declared as spent fuel or radioactive waste for the purposes of this Convention by the Contracting Party. However, this Convention shall apply to the safety of management of spent fuel and radioactive waste from military or defence programmes if and when such materials are transferred permanently to and managed within exclusively civilian programmes.

(4) This Convention shall also apply to discharges as provided for in Articles 4, 7, 11, 14, 24 and 26.

C.1 Spent fuel and radioactive waste from civil use of nuclear energy

The scope of this Article and therefore the obligation of reporting encompasses the safety of the management of the spent fuel from German nuclear power plants and research reactors which is stored with the intention of disposal. Furthermore, the scope of this Article encompasses the safety of management of radioactive waste from the operation and decommissioning of German nuclear facilities and research reactors as well as from the use for medical, industrial and research purposes, and is therefore subject to reporting.

Spent fuel from research reactors which is returned to its country of origin is outside the scope of the Joint Convention and is therefore exempt from reporting.

C.2 Distinction between NORM and radioactive waste

In Germany, Council Directive 2013/59/EURATOM [1F-24] of 5 December 2013 is currently being transposed into the national radiation protection legislation. Nevertheless, on the date of reference of this national report, the legal situation which is based, i.a., on Council Directive 96/29/EURATOM is still valid. Accordingly, a distinction is drawn between regulations for radioactive material from nuclear facilities and other handling licensed according to radiation protection legislation on the one hand, and waste that contains only naturally occurring radioactive material (NORM) on the other hand. For NORM, some of the applicable requirements (e.g., with regard to exemption provisions) are principally different from requirements applicable to radioactive material from nuclear facilities and other handling, which is licensed according to nuclear or radiation protection legislation. In keeping with the Basic Safety Standards of the European Union applicable so far, the German Radiation Protection Ordinance (StrlSchV) [1A-8] makes a distinction between

- practices, which are regulated in Part 2 StrlSchV and which refer to the use of radioactive material and ionising radiation, and
- work activities, which are regulated in Part 3 StrlSchV and which refer to natural sources of radiation.

The distinction between these two terms is explained in the sections C.2.1 and C.2.2 on the basis of the definitions provided in § 3 StrlSchV. Modifications resulting from the new Radiation Protection Act (StrlSchG) [1A-29b] are addressed in Section C.2.3.

C.2.1 Practices

The term “practices” refers to the use of a material's radioactive properties. This may include, for example, the operation of nuclear facilities, fuel fabrication, isotope production, and applications of radioactive material, especially radioactive sources, e.g. in industry and research. The safety of radioactive waste management as defined by this Article of the Joint Convention encompasses all radioactive waste from practices. This is further dealt with in this national report.

C.2.2 Work activities

The term “work activities” refers to actions involving materials which, although containing naturally occurring radionuclides, are not used for their radioactive properties. Of importance for the protection of the population is the recycling or disposal of residues from certain industrial processes with elevated contents of naturally occurring radionuclides of the U-238, U-235 and Th-232 decay chains. Examples include excavated materials from mining activities, fly ashes from combustion processes, residues from flue-gas purification of coal-fired power plants and slag from ore smelting. So, among other things, their use as construction aggregate is to be limited. Until now, only very small amounts of radioactive waste within the meaning of the Joint Convention have originated from work activities. In the following, an overview is given of the field of work activities and the related residues with elevated natural radioactivity.

Legal bases

In its Part 3, the StrlSchV regulates the protection of man and the environment against natural radioactivity in connection with work activities (§§ 93 to 104 StrlSchV [1A-8]). The regulations referring to residues and other materials from work activities are found in §§ 97 to 102 StrlSchV. The radiological protection goal for individuals of the population is set by the reference level of the effective dose to 1 mSv/a by § 97(1) StrlSchV.

According to § 97(1) StrlSchV, anyone engaged or permitting engagement on his own responsibility in work activities where residues requiring surveillance accumulate and where the utilisation or disposal thereof may cause the effective dose reference criterion for the general public of 1 mSv/a to be exceeded shall take measures for the protection of the general public. The requirement for surveillance of these residues is regulated in § 97(2) in conjunction with Appendix XII, Part A StrlSchV. Appendix XII, Part A includes the list of residues which have to be taken into account with specification of the application areas and branches in which such residues may arise and which may, in principal, lead to exceeding the 1 mSv/a dose criterion. The list includes the following materials

1. Sludges and sediments from the recovery of oil and natural gas;
2. Unconditioned phosphoric plasters, sludges from their preparation as well as dust and cinder from the processing of raw phosphate (phosphorite);
3. a) country rock, sludges, sand, cinder and dust
   - from the extraction and preparation of bauxite, columbite, pyrochlore, microlyth, euxenite, copper shale, tin, rare earths and uranium ores,
   - from the processing of concentrates and residues that occur with the extraction and preparation of these ores and minerals, as well as

   b) minerals corresponding to the above specified ores that occur with the extraction and preparation of other raw materials.
4. Dust and sludges from smoke gas filtering with the primary metallurgic processes in the raw iron and non-ferrous metallurgy.

Residues according to § 97 StrlSchV [1A-8] are also

a) materials in accordance with subparas. 1 et seq., when the occurrence of these materials is deliberately produced,

b) castings from the materials specified in subparas. 1 et seq., as well as

c) excavated or cleared ground and demolition waste from the dismantling of buildings or other structures when these contain residues in accordance with the subparas. 1 et seq. and are removed in accordance with § 101 StrlSchV after completion of the work activities or in accordance with § 118(5) StrlSchV from properties.

The possibility of exceeding the 1 mSv/a dose criterion has been carefully checked for each of the listed residues by extensive studies during the development phase of these regulations. These studies have been based on the actual material streams and exposure conditions that are relevant for Germany.

Release from surveillance

Residues from the list given above are initially assumed to require surveillance. However, if the specific activity of those residues is lower than the surveillance limits provided in Appendix XII, Part B of the StrlSchV [1A-8], surveillance is not required according to § 97(2) StrlSchV. If the surveillance limits are exceeded and it can be demonstrated in a case-specific evaluation according to § 98(1) StrlSchV that the 1 mSv/a dose criterion is not exceeded, the competent authorities of the respective *Land* may release the residues from surveillance. The criteria listed in Appendix XII, Part C StrlSchV can be applied in this procedure.

The surveillance limits provided in Appendix XII, Part B StrlSchV have been derived on the basis of extensive radiological studies. If they are complied with, it is at the same time assured that the 1 mSv/a dose criterion will not be exceeded. The surveillance limits are a tiered set of specific activity values (in Bq/g) referring to the greatest values of any nuclide in the decay chains of U-238sec and Th-232sec. The limit values range from 0.2 Bq/g to 5 Bq/g, depending on the kind of intended use or disposal. When applying the surveillance limits, a summation rule has to be observed.

Residues remaining under surveillance

If it is not possible to release a residue from surveillance, it has to remain in surveillance. The corresponding procedure is laid down in § 99 of the StrlSchV [1A-8]. It prescribes that the person who is responsible according to § 97(1) StrlSchV must declare to the competent authority within one month the type, mass and specific activity of the residues requiring surveillance as well as any intended disposal or utilisation of these residues or the delivery for these purposes. The competent authority may rule that protective measures are to be taken and may specify the manner in which the residues are to be disposed of.

In those cases where a disposal of the residues remaining under surveillance is required, means for storage of the residues, if necessary under institutional control, have to be generated in order to comply with the protection targets.

In order to cover unforeseen cases or potential incompleteness of the regulations in Appendix XII, Part A StrlSchV, § 102 StrlSchV has been introduced to provide a rule for such cases where due to work with materials that are not residues according to Appendix XII, Part A StrlSchV or due to the execution of work where such materials accumulate, the radiation exposure of members of the public will be increased so significantly that radiation protection activities are necessary. In such cases, the competent authority takes the appropriate measures, in particular by prescribing that certain protective measures are to be taken, that the materials are to be kept or stored at a site designated by it, or that and how the materials are to be disposed of.

Experience from application of the regulations

Compliance with the surveillance limits or the dose criterion with respect to the residues has been verified for a large number of companies using higher level NORM on the basis of the regulations described above. Various material streams have been investigated. In all cases which have been dealt with so far, it was found that the surveillance limits were not exceeded or that compliance with the dose reference level on the basis of case-specific evaluations could be demonstrated. Incrustations from the oil and gas industry, for which compliance with the dose reference level cannot be demonstrated, could have been handed over to *Land* collecting facilities so far due to their low total amount. However, two main problems with the disposal of NORM residues arise for the future. On the one hand, the number of landfills where NORM residues can principally be disposed of decreases and, on the other hand, the readiness to accept these NORM residues at the still-existing landfills continues to decline.

The list of residues classified as requiring surveillance (Appendix XII, Part A of the StrlSchV) is regularly reviewed. So, for example, the use of geothermal energy for the production of energy (electricity, district heating) has been increasing in recent years. The depositions removed during the regularly scheduled cleaning of circuits and heat exchangers are no residues requiring surveillance according to Appendix XII, Part A StrlSchV but, depending on the site, they contain activity of nuclides of the U and Th decay series that are not insignificant. The management of such residues takes currently place on the basis of the provisions of § 102 StrlSchV and it is checked whether they require surveillance. The same applies to filter residues from water treatment if uranium or radium is removed from the water.

Against this background, in the context of the transposition of Council Directive 2013/59/EURATOM [1F-24], different aspects with regard to NORM residues and work activities are currently investigated within research projects of the Federal Office for Radiation Protection, especially the determination of potential radiation exposures resulting from discharges from the relevant industries and the determination and evaluation of radiation exposure at workplaces by means of NORM.

C.2.3 Future amendments resulting from the new Radiation Protection Act

The new StrlSchG [1A-29b] in conjunction with the respective ordinances includes the following significant amendments with regard to NORM:

- The previous distinction between “work activities” and “practices” is omitted. In future, handling of radioactive materials and actions referring to NORM are considered as practices.
- The limit for the sum of the effective doses arising from exposures from all practices requiring a licence or a registration is 1 mSv/a. Where applicable, simultaneously occurring exposures due to practices, including NORM practices, previously categorised as “work activities” thus are to be evaluated jointly, provided that these require a licence or a registration.
- The starting point for occupational exposure monitoring regarding NORM practices is an effective dose exceeding 1 mSv/a compared with 6 mSv/a previously.
- The requirement to reduce exposures now also applies to NORM practices, including the so-called NORM workplaces.

The distinction between artificially generated and naturally occurring radioactive materials remains, though, as well as the assessment bases for exemption of 10 µSv/a for artificially generated radioactive materials and 1 mSv/a for NORM.

C.3 Spent fuel and radioactive waste from the military sector

There is no spent fuel from military or defence programmes in Germany.

The treatment and storage of radioactive waste from military or defence programmes remains the responsibility of the armed forces and is not transferred to civil responsibility until the waste is delivered to a repository. Until then, it is stored in a central collecting facility. If necessary, the waste will previously be conditioned according to the acceptance criteria of the repository for disposal. All these waste management stages are subject to the same safety provisions as those applicable in the civil sector.

C.4 Radioactive discharges

The scope of the Joint Convention and therefore the obligation of reporting encompasses also the radioactive discharges as provided for in Articles 4, 7, 11, 14, 24 and 26. Reporting on provisions and measures related to limitation of radioactive discharges is documented in the corresponding sections.

D Inventories and lists

This section deals with the obligations under Article 32 (2) of the Convention.

Developments since the Fifth Review Meeting:

According to the amendments to the Atomic Energy Act (AtG) [1A-3] in connection with the Repository Site Selection Act (StandAG) [1A-7a], the vitrified radioactive waste from reprocessing still to be returned must be stored in on-site storage facilities until it is delivered to a facility for disposal. The *Länder* of Schleswig-Holstein, Baden-Wuerttemberg, Hesse and Bavaria have agreed to take over this waste.

With the decision of the Federal Administrative Court of 8 January 2015, the storage licence for the on-site storage facility at the Brunsbüttel nuclear power plant became ineffective. On 16 November 2015, the operator submitted an application for a new licence for the storage of nuclear fuel according to § 6 AtG. On 11 January 2017, the necessary documents were displayed for public participation.

At the AVR cask storage facility in Jülich, the licensing procedure could not be completed until expiry of the second storage order on 31 July 2014. Consequently, on 2 July 2014, the nuclear supervisory authority gave order to remove the nuclear fuel from the AVR cask storage facility. In the autumn of 2014, the operator presented a concept for removal which, as one of three options, provides for the storage of the fuel spheres in the Ahaus transport cask storage facility. The Federal Office for Radiation Protection (BfS) granted a corresponding modification licence for the Ahaus transport cask storage facility on 21 July 2016.

At the site of the Konrad repository, the construction measures have been continued. Underground, the six emplacement chambers of storage field 5/1 and the return air collection roadway were driven. Refurbishment of the infrastructure galleries as well as driving of the workings for the workshop area and for processing of backfill material are currently underway. The administrative and social building is under construction.

Article 32 (2): Reporting

(2) This report shall also include

i) a list of the spent fuel management facilities subject to this Convention, their location, main purpose and essential features;

ii) an inventory of spent fuel that is subject to this Convention and that is being held in storage and of that which has been disposed of. This inventory shall contain a description of the material and, if available, give information on its mass and its total activity;

iii) a list of the radioactive waste management facilities subject to this Convention, their location, main purpose and essential features;

iv) an inventory of radioactive waste that is subject to this Convention that

a) is being held in storage at radioactive waste management and nuclear fuel cycle facilities;

b) has been disposed of; or

c) has resulted from past practices.

This inventory shall contain a description of the material and other

> *appropriate information available, such as volume or mass, activity and specific radionuclides;*
>
> *v) a list of nuclear facilities in the process of being decommissioned and the status of decommissioning activities at those facilities.*

The sites of storage facilities for spent fuel and radioactive waste, as far as they have not been constructed at the locations of nuclear power plants that were in operation at the time of the construction of the storage facilities, as well as of facilities for conditioning and disposal are shown in Figure D-1.

Figure D-1: Sites of facilities of spent fuel and radioactive waste management (without on-site storage facilities and facilities covered by licences pursuant to § 7 AtG)

D.1 Spent fuel management facilities

The spent fuel unloaded from the reactor core is first placed in fuel pools inside the reactor buildings for several years. These pools serve to allow the required decay of activity and heat generation until the fuel is placed in transport and storage casks for storage and provide the operator with sufficient flexibility to operate the facility. A particular case is the additional wet storage facility outside the reactor building in Obrigheim. As this facility, like the spent fuel pools inside the reactor buildings, is regarded to be part of the power plant operation from a licensing point of view, it will not be dealt with further in this report. It is, however, included in Table D-1, Table L-1 and Chapter D.1.2 for the sake of completeness. Transport of the fuel assemblies to the Neckarwestheim on-site storage facility will be carried out by early 2018. A corresponding modification licence for the Neckarwestheim storage facility was granted on 9 August 2016.

The following facilities shall be considered as spent fuel management facilities within the meaning of the Joint Convention:

- the on-site storage facilities of nuclear power plants,
- the central storage facilities in Ahaus, Gorleben and Rubenow,
- the AVR cask storage facility in Jülich,
- the pilot conditioning plant in Gorleben.

Detailed information on existing and planned facilities can be found in Annex L–(a). The overviews given there also include the spent fuel pools inside the reactor buildings.

The spent fuel reprocessing plant at Karlsruhe (WAK) is dealt with within the reporting on Article 32(2)(v).

Table D-1: Storage facilities and conditioning plants for spent fuel as at 31 December 2016
a) Spent fuel storage facilities b) Conditioning plants

a) Spent fuel storage facilities

Site	Storage capacity		Status		Emplaced
	Positions for casks / fuel assemblies	[Mg HM]	Licensed	Applied for	[Mg HM]
Fuel pools inside reactor buildings					
Nuclear power plants in total	19,587 FA positions[1)]	approx. 6,078[1)]	x		3,509
Fuel pools outside reactor buildings					
Obrigheim (KWO)	980 FA positions[2)]	286	x		100
On-site storage facility (dry storage)					
Biblis (KWB)	135 cask positions	1,400	until 2046		723
Brokdorf (KBR)	100 cask positions	1,000	until 2047		281
Brunsbüttel (KKB)	80 cask positions	450		2015	89
Grafenrheinfeld (KKG)	88 cask positions	800	until 2046		204
Grohnde (KWG)	100 cask positions	1,000	until 2046		293
Gundremmingen (KRB)	192 cask positions	1,850	until 2046		413
Isar (KKI)	152 cask positions	1,500	until 2047		338
Krümmel (KKK)	80 cask positions	775	until 2046		252
Lingen/Emsland (KKE)	130 cask positions[3)]	1,250	until 2042		368
Neckarwestheim (GKN)	151 cask positions	1,600	until 2046		456
Philippsburg (KKP)	152 cask positions	1,600	until 2047		522
Unterweser (KKU)	80 cask positions	800	until 2047		262
Obrigheim (KWO)	15 cask positions	100		2005	
Central storage facility (dry storage)					
Gorleben	420 cask positions[4)]	3,800	until 2034		37[5)]
Ahaus	420 cask positions[6)]	3,960	until 2036		55[7)]
Decentralised storage facility (dry storage)					
Rubenow	80 cask positions	585	until 2039		583
Jülich	158 casks	0.225[8)]	until 30.06.2013	extended[9)]	0.086

1) Part of the storage capacity has to be kept free for unloaded cores.
2) Obrigheim nuclear power plant has a wet storage facility outside of the reactor building that was commissioned in 1999. Transport of the fuel assemblies to the Neckarwestheim storage facility will be carried out by early 2018.
3) Licensed for 125 cask positions for loaded casks and 5 casks positions for empty casks.
4) Including the positions for HAW canisters.
5) An additional 2 Mg HM in the HAW canisters.
6) Including cask positions in storage area I, for which a licence for storage of waste from operation and decommissioning was granted according to § 7 of the Radiation Protection Ordinance (StrlSchV) on 26 May 2010 for a maximum of 10 years.
7) Total amount from power reactors, an additional approx. 6 Mg HM from the Hamm-Uentrop thorium high temperature reactor (THTR) and 2 Mg HM from the Rossendorf research reactor (RFR).
8) Thermally fissile isotopes (U-233, U-235, Pu-239, Pu-241).
9) The licensing procedure for extending the storage could not be completed by 31 July 2014. On 2 July 2014, an order was issued on the removal of the nuclear fuel from the AVR cask storage facility.

b) Conditioning plant

Plant	Site	Purpose	Maximum throughput	Status
PKA	Gorleben	Conditioning of spent fuel for direct disposal and for the treatment of radioactive waste; presently only repair of damaged casks	35 Mg HM/a (conditioning)	Licensed and constructed but not yet in nuclear operation

D.1.1 On-site storage facilities of nuclear power plants

The concept of the Federal Republic of Germany envisages that the spent fuel will be stored at the sites of the nuclear power plants. It should generally remain at the sites where it is produced until it can be conditioned to meet the requirements for disposal and be disposed of. On-site storage means that spent fuel transports will be avoided until disposal of the fuel with prior conditioning.

On-site storage facilities for spent fuel were licensed under nuclear law and constructed and commissioned at twelve sites with nuclear power plants. They are designed as dry storage facilities in which transport and storage casks loaded with spent fuel are emplaced.

The storage facilities are cooled by passive air convection which removes the heat from the casks independently of any active technical systems. The leak-proof and accident-resistant casks ensure safe enclosure as well as the necessary degree of radiation shielding and criticality safety during both normal operation and in the case of incidents. Protection against external hazards, such as earthquakes, blast waves and aircraft crashes, is ensured by the thick walls of the casks. It was demonstrated and confirmed in the licensing procedure that the casks are suitable for at least 40 years of storage. Thus, the licences limit the storage period to 40 years, starting with the emplacement of the first cask. These licences may only be renewed on imperative grounds and after this issue has been discussed in the German *Bundestag*.

At the Obrigheim nuclear power plant, an extension of the wet storage capacity in a pool outside the reactor building was licensed in 1998. The spent fuel remaining in the power plant after its shutdown in May 2005 was previously stored in the on-site wet storage facility. It is planned to move it to the Neckarwestheim storage facility. A corresponding modification licence for the Neckarwestheim storage facility for storage of the Obrigheim fuel assemblies was granted on 9 August 2016. The licence for the transport of the casks by ship via the river Neckar was granted on 16 May 2017. The first fuel assemblies were emplaced at the Neckarwestheim on-site storage facility at the end of June 2017. It is expected that by the end of the first quarter of 2018, all fuel assemblies will have been removed from Obrigheim.

At the Brunsbüttel nuclear power plant, the licence for the on-site storage facility granted in 2003 became ineffective with the decision of the Federal Administrative Court of 8 January 2015. The decision of the Federal Administrative Court was not made because of shortcomings in safety of the storage facility. The courts have not expressed their opinion on the issue of actual safety. In the judgement, the scope of investigations and assessments in the licensing procedure was criticised. The legal basis for the storage of spent fuel in the Brunsbüttel on-site storage facility is currently an order according to § 19 of the Atomic Energy Act (AtG) [1A-3] of the competent nuclear supervisory authority, the Ministry of Energy Transition, Agriculture, the Environment and Rural Areas of the *Land* of Schleswig-Holstein. On 16 November 2015, an application was filed for a new licence for the storage of nuclear fuel according to § 6 AtG in the on-site storage facility. The licensing procedure takes place with the participation of the public. The documents required for it were laid open for public inspection at the Federal Office for the Safety of Nuclear Waste

Management (BfE), the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and the Citizens' Office of the city of Brunsbüttel on 11 January 2017.

D.1.2 Central storage facilities

Gorleben transport cask storage facility

The Gorleben transport cask storage facility is licensed for the storage of nuclear fuels in the form of spent fuel from light water reactors as well as of HLW canisters (vitrified high level fission product solutions from reprocessing of German fuel assemblies). The latest modification licence from 2010 allows storage in casks of the newer type CASTOR® HAW 28M. The storage facility is designed as a dry storage facility.

According to the AtG, solidified fission product solutions from reprocessing abroad are to be returned and stored in on-site storage facilities. For conditioned radioactive waste with negligible heat generation which is currently stored in the Gorleben waste storage facility, storage in a separate section within the transport cask storage facility was applied for in December 2013.

Figure D-2 shows an aerial photograph and Figure D-3 a view into the transport cask storage facility at the Gorleben site. Further information on the storage facility in Gorleben can be found in Table L-2 of the annex.

Figure D-2: Pilot conditioning plant (PKA), Gorleben transport cask storage facility (TBL-G) and Gorleben waste storage facility (ALG) of the Brennelemente-Lager Gorleben GmbH (BLG) (Copyright: GNS)

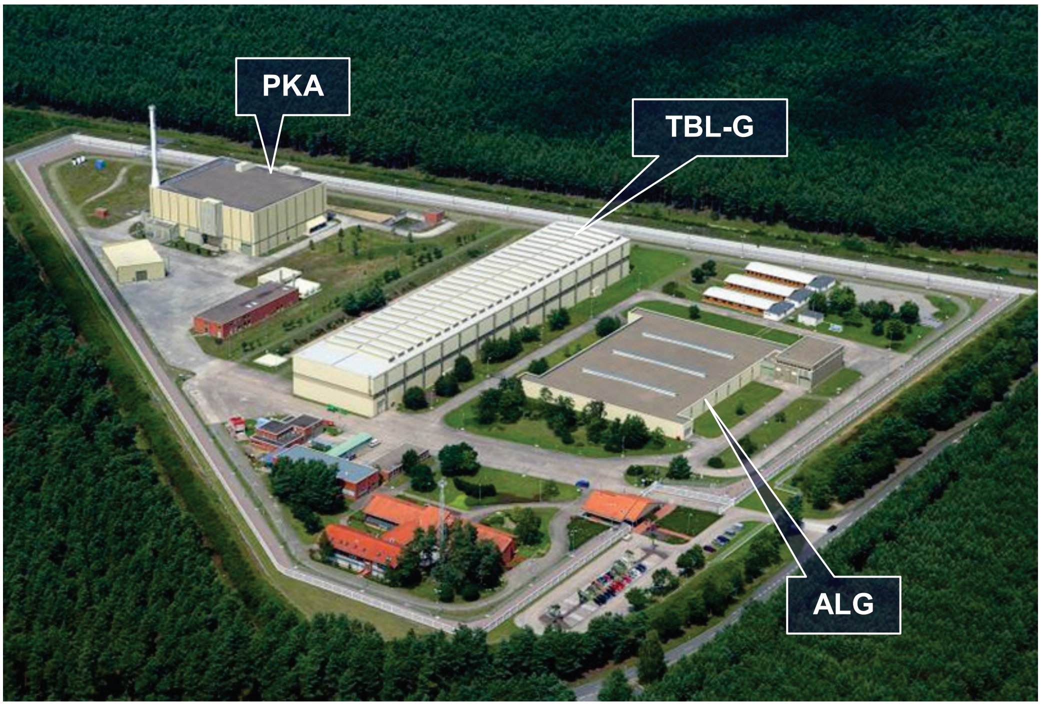


Figure D-3: View into the Gorleben transport cask storage facility (Copyright: GNS)

Ahaus transport cask storage facility

According to the licence granted, spent fuel from various German nuclear power plants may also be stored in the Ahaus transport cask storage facility. In addition, the Ahaus transport cask storage facility is also licensed as a central storage facility for the storage of transport and storage casks of the CASTOR® THTR/AVR and MTR 2 types, in which spent fuel from experimental, demonstration and research reactors is stored. It is therefore intended to use the Ahaus cask storage facility also for the storage of further spent fuel from research reactors (the Berlin experimental reactor II (BER II), the Research Neutron Source Heinz Maier-Leibnitz (FRM II) of the Technical University of Munich, the TRIGA Mark II research reactor in Mainz) in casks of the CASTOR® MTR 3 type. By letter of 30 September 2014, the GNS Gesellschaft für Nuklear-Service mbH (GNS) asked for resuming the nuclear licensing procedure for the storage of the spent fuel from the FRM II of the Technical University of Munich in the Ahaus transport cask storage facility.

By letter of 24 September 2009, the Brennelement-Zwischenlager Ahaus GmbH (BZA) and GNS filed an application at the Federal Office for Radiation Protection (BfS) according to § 6 AtG [1A-3] for the storage of nuclear fuel in the form of spent fuel elements and other radioactive material in the form of operational elements (absorber and graphite elements with no fissile material content) from the former experimental nuclear reactor at Jülich (AVR) of the AVR GmbH Jülich, in a total of 152 transport and storage casks of the CASTOR® THTR/AVR type in the eastern part of the two storage areas (storage area II), which is currently stored in the AVR cask storage facility at the site of the Forschungszentrum Jülich GmbH (FZJ). After interim suspension of the licensing procedure, it was resumed in January 2015 and concluded by the BfS on 21 July 2016 with the granting of the 8th modification licence for the Ahaus transport cask storage facility.

Furthermore, the storage of high-pressure compacted radioactive waste (the CSD-C from reprocessing at La Hague) in the Ahaus transport cask storage facility was applied for. Currently, a cask concept for 27 canisters each is under development.

On 9 November 2009, the district government of Münster granted a licence according to § 7 of the Radiation Protection Ordinance (StrlSchV) [1A-8] for the temporary storage of waste from operation and decommissioning in the western part of the two storage areas (storage hall I) of the Ahaus transport cask storage facility. The storage period is limited to ten years. On 21 July 2010, the first waste packages were emplaced. On 29 August 2016, the operators filed an application at the competent nuclear licensing and supervisory authority for a perpetual licence for the handling of other radioactive substances in the form of storage in storage hall I of the Ahaus transport cask storage facility. The applicant is obliged to carry out an environmental impact assessment.

Figure D-4 shows an aerial photograph and Figure D-5 a view into the transport cask storage facility at the Ahaus site. Further information on the storage facility in Ahaus can be found in Table L-2 of the annex.

Figure D-4: Transport cask storage facility Ahaus for spent fuel and radioactive waste (Copyright: GNS)

Figure D-5: Transport cask storage facility Ahaus (Copyright: GNS)
left: CASTOR® V and CASTOR® THTR/AVR
right: CASTOR® MTR 2 between CASTOR® THTR/AVR

Zwischenlager Nord (ZLN)

In addition to spent fuel from the Soviet-type reactors at Rheinsberg and Greifswald, spent and fresh fuel from the compact sodium-cooled nuclear reactor plant (KNK II), from the nuclear ship

Otto Hahn as well as HAW glass canisters from the WAK are currently stored in the Zwischenlager Nord (ZLN). The KNK fuel rods were emplaced in 2010, the HAW glass canisters in 2011.

Further information on the storage facility in Rubenow can be found in Table L-2 of the annex.

D.1.3 AVR cask storage facility in Jülich

In the AVR cask storage facility in Jülich the spent fuel spheres from the operation of the AVR are stored in 152 transport and storage casks of the CASTOR® THTR/AVR type. The original storage licence granted by the BfS on 17 June 1993 had been limited to 20 years. On 26 June 2007 and with a more precise letter dated 29 April 2009, the FZJ applied for the storage of AVR fuel elements in the Jülich storage facility for another three years from 1 July 2013. After the FZJ had asked to suspend the licensing procedure on 16 July 2010, the BfS resumed the procedure at the FZJ's request of 16 May 2012 and has been continuing it since then. On the part of the applicant, the licensing procedure has been led by the AVR GmbH since 1 September 2015, which was merged with the nuclear areas of the FZJ as of 1 September 2015, into the new Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH (JEN).

After expiry of the storage licence of 1993 on 1 July 2013 the application for continued operation of the AVR cask storage facility could not be granted yet by the BfS. Therefore, the then Ministry of Economic Affairs, Energy, Industry, SMEs and Crafts of North Rhine-Westphalia (MWEIMH), as the competent nuclear supervisory authority, issued temporary orders on 27 June 2013 and 17 December 2013 on the basis of the general licensability of the licence applied for at the BfS for the further storage of the nuclear fuel from the AVR in the AVR cask storage facility in Jülich. It was not possible to conclude the licensing procedure until expiry of the second storage order on 31 July 2014 either, since the safety demonstrations with regard to seismic safety could not be provided within the licensing procedure. Consequently, on 2 July 2014, the nuclear supervisory authority gave order to remove the nuclear fuel from the AVR cask storage facility, and the previous order of 17 December 2013 was suspended.

The operator developed a concept for the removal of the fuel from the facility according to specific requirements from the order and presented it to the MWEIMH. This concept provides for three options, whose sequence in which they are presented does not imply a priority listing from the technical view:

1. transport of the nuclear fuel to the Ahaus transport cask storage facility,
2. transport of the nuclear fuel to their country of origin, the United States of America, and
3. transport of the nuclear fuel to a new storage facility to be built at the Jülich site.

The nuclear supervisor has commissioned an authorised expert according to § 20 AtG as well as a legal expert with the assessment of the concept in the sense of a plausibility check of the described processes, in particular with regard to issues related to safety and security, and with a legal assessment with regard to issues related to nuclear, environmental, transport and hazardous goods law.

According to the current state of knowledge, it is not yet foreseeable which of the three options will be chosen by JEN. Due to the extent and complexity of the issues to be examined, none of the three options is ready for decision yet. Government custody according to § 5 AtG can be ruled out.

On 21 July 2016, the BfS granted the operator of the Ahaus storage facility the licence according to § 6 AtG for emplacement of the 152 casks of the CASTOR® THTR/AVR type, which are currently stored in Jülich. In addition, a transport of the casks from Jülich to Ahaus also requires a transport licence according to § 4 AtG. It is not yet foreseeable when the licence can be granted.

Further information on the storage facility in Jülich can be found in Table L-2 of the annex.

D.1.4 Pilot conditioning plant

The reference concept for direct disposal of spent fuel in a salt dome pursued until the entry into force of the Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste and for the Amendment of Other Laws (Repository Site Selection Act – StandAG) [1A-7a] envisaged the removal of the fuel rods from the fuel assemblies in an above-ground facility, the packaging of the fuel rods in self-shielding and sealed thick-walled casks and their emplacement in deep geological formations for disposal. In accordance with the type of cask used, it is also referred to as the POLLUX reference concept. In order to demonstrate the conditioning technique, a pilot conditioning plant (PKA) was completed in Gorleben in 2000. The plant is licensed for a throughput of 35 Mg HM/a. According to the agreement between the Federal Government and the utilities of 11 June 2001, the use of the plant is licensed only for the repair of defective casks for spent fuel from light water reactors and for vitrified HAW from reprocessing as well as for the handling of other radioactive material.

Further information on the PKA in Gorleben can be found in Table L-3 of the annex.

D.2 Spent fuel inventory

An overview of the spent fuel from German power reactors by the end of 2016 is given in Table D-2 (classified according to place of origin) and Table D-3 (classified according to whereabouts). Table D-4 shows the whereabouts of the spent fuel from experimental and demonstration reactors.

D.2.1 Spent fuel quantities

Power reactors

In the spent fuel pools of the power plants (including the Obrigheim on-site storage facility designed for wet storage) and in the core of the decommissioned Brunsbüttel nuclear power plant, there is a total 3,609 Mg HM of spent fuel assemblies (as at 31 December 2016).

The on-site storage facilities, which are designed for dry storage, hold 4,201 Mg HM, and the central storage facilities in Ahaus and Gorleben hold 92 Mg HM. The inventory is in the form of light water reactor (LWR) spent fuel assemblies which are stored in storage casks. 583 Mg HM VVER fuel assemblies from Rheinsberg and Greifswald are stored in transport and storage casks in the Zwischenlager Nord (ZLN) near Greifswald. A total of 6,670 Mg HM spent fuel assemblies have already been removed from the nuclear power plants either for reprocessing or for permanently remaining abroad. The major part was sent to the La Hague and Sellafield reprocessing plants. Table D-3 gives an overview of the whereabouts of the spent fuel.

As at 31 December 2016, there was a total of about 15,155 Mg HM in the form of spent fuel from the operation of the German light water reactors still in operation and shut down with capacities > 50 MW (see Table D-2), around 67 Mg HM of which had been produced in 2016. A part of the spent fuel assemblies in the fuel pools have not yet reached their final burn-up and are therefore intended for reuse in the reactors at a later point in time. However, as the Joint Convention makes no distinction in this respect, the spent fuel intended for reuse has been considered in the spent fuel quantities given in this report (e.g. in Table D-2 and Table D-3).

Table D-2: Quantities of spent fuel produced in light water reactors (power > 50 MW) in the Federal Republic of Germany as at 31 December 2016

Type	Abbr.	Power plant, site	Total quantities	
			Number FAs	[Mg HM]
Plants in operation				
PWR	KBR	Brokdorf	1,356	717
PWR	KWG	Grohnde	1,512	802
PWR	KKE	Emsland	1,384	724
PWR	KKP 2	Philippsburg 2	1,464	774
PWR	GKN II	Neckarwestheim II	1,249	648
BWR	KRB-B	Gundremmingen B	4,732	814
BWR	KRB-C	Gundremmingen C	4,545	780
PWR	KKI 2	Isar 2	1,296	678
Subtotal:			**17,538**	**5,937**
Authorisation for power operation for electricity production expired				
BWR	KKB	Brunsbüttel	2,664	459
BWR	KKK	Krümmel	3,909	680
PWR	KKU	Unterweser	1,717	908
PWR	KKG	Grafenrheinfeld	1,725	915
Subtotal:			**10,015**	**2,962**
Plants under decommissioning				
BWR	KWL	Lingen	586	66
BWR	KRB-A	Gundremmingen A	1,028	125
BWR	KWW	Würgassen	1,989	346
PWR	KMK	Mülheim-Kärlich	209	96
PWR	KWO	Obrigheim	1,235	352
PWR	KKS	Stade	1,517	539
PWR	KKR	Rheinsberg	918	106
PWR	KGR 1-5	Greifswald 1-5	6,813	787
PWR	KWB-A	Biblis Unit A	1,676	877
PWR	KWB-B	Biblis Unit B	1,824	964
BWR	KKP 1	Philippsburg 1	3,632	632
PWR	GKN I	Neckarwestheim I	1,830	648
BWR	KKI 1	Isar 1	4,072	718
Subtotal			**27,329**	**6,256**
Total:			**54,882**	**15,155**

Note: The quantities given in Mg HM are rounded to the nearest whole number. This may result in minor differences in the total compared to other figures published. The Mg HM quantities partly refer to data provided by the operators.

Table D-3: Overview of total quantities of spent fuel assemblies from German light water reactors (power > 50 MW) as at 31 December 2016

Place of storage/whereabouts	Quantity [Mg HM]
Spent LWR fuel in NPP spent fuel pools (incl. wet storage facility outside the KWO reactor building)	3,609
Dry storage of spent VVER fuel in casks at ZLN	583
On-site dry cask storage	4,201
Dry cask storage at the Ahaus and Gorleben storage facilities	92
Shipped to La Hague (France) for reprocessing	5,393
Shipped to Sellafield (United Kingdom) for reprocessing	851
Reprocessed at the Karlsruhe reprocessing plant (WAK)	85
Reprocessed at the EUROCHEMIC reprocessing plant (Belgium)	14
Returned to the former USSR (VVER fuel)	283
Shipped to Sweden without return (CLAB)	17
Reuse of VVER fuel at Paks (Hungary)	27
Total	**15,155**

Note: The quantities given in Mg HM are rounded to the nearest whole number. This may result in minor differences in the total compared to other figures published. The Mg HM quantities partly refer to data provided by the operators.

Experimental and demonstration reactors

Apart from the above-mentioned reactors, eight experimental and demonstration reactors were operated in the Federal Republic of Germany, which are all under decommissioning or have already completely been dismantled. These are:

- experimental nuclear reactor at Jülich (AVR), Jülich,
- Hamm-Uentrop thorium high temperature reactor (THTR-300), Hamm,
- multi-purpose research reactor (MZFR), Karlsruhe,
- compact sodium-cooled nuclear reactor plant II (KNK II), Karlsruhe,
- Kahl experimental nuclear power plant (VAK), Kahl,
- pressure tube reactor at Niederaichbach (KKN), Niederaichbach,
- superheated steam reactor (HDR), Großwelzheim,
- nuclear ship Otto Hahn, Geesthacht.

More details on these reactors are given in Table L-17 in Annex L-(c). The destinations and corresponding quantities of heavy metals for storage or reprocessing of the accumulated approx. 190 Mg HM spent fuel assemblies are summarised in Table D-4.

Table D-4: Management of spent fuel from experimental and demonstration reactors as at 31 December 2016

Reactor	Quantities stored or reprocessed in Mg HM									Σ
	WAK	**BNFL**	**SKB**	**CEA**	**EURO-CHEMIC**	**FZ Jülich**	**TBL Ahaus**	**ZLN**	**Others**	
VAK	7.9	0.1	6.5		7.4				0.1	22.0
MZFR	89.6	10.6	0.4							100.6
KKN				46.3						46.3
KNK II				1.4				0.5	0.2	2.1
AVR						1.9				1.9
THTR							6.9			6.9
HDR	6.9									6.9
Otto Hahn	2.9							«0.1		2.9
Total	**107.3**	**10.7**	**6.9**	**47.7**	**7.4**	**1.9**	**6.9**	**0.5**	**0.3**	**189.6**

Most of the spent fuel listed in Table D-4 was reprocessed at the Karlsruhe reprocessing plant (WAK), at BNFL or at EUROCHEMIC in Belgium. A smaller part was shipped to SKB in Sweden and to CEA in France and will remain there. The THTR fuel spheres are stored at the Ahaus transport cask storage facility. They have been reported so far as an intermediate waste product and not as spent fuel. The AVR fuel spheres are stored at the Forschungszentrum Jülich GmbH (FZJ). 152 casks contain around 290,000 fuel spheres with 1.9 Mg HM (including thorium).

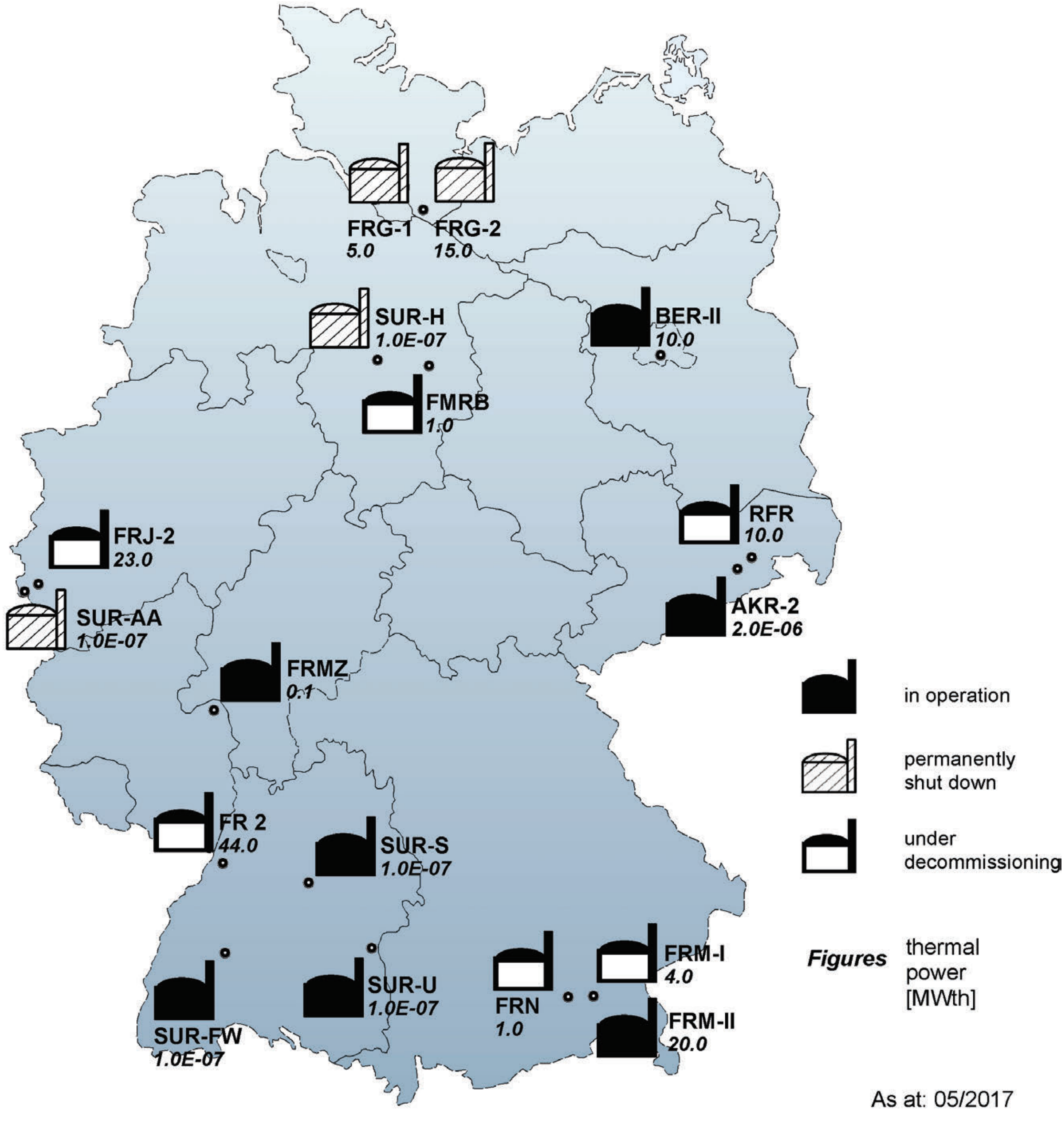
Research and training reactors

Seven training and research reactors are in operation in Germany. These are:

- the Berlin experimental reactor II (BER II),
- the Research Neutron Source Heinz Maier-Leibnitz (FRM II) of the Technical University of Munich,
- the TRIGA Mark II research reactor in Mainz, and
- four reactors for training and educational purposes, three of them Siemens reactors for training purposes (SURs) and one reactor for educational purposes (AKR-2).

The geographical location of the research reactors in Germany is shown in Figure D-6.

Figure D-6: Research and training reactors in Germany



The Jülich research reactor (FRJ-2 DIDO) was permanently shut down on 2 May 2006 and the decommissioning licence was granted on 20 September 2012. For the research reactor Geesthacht-1 (FRG-1) which was permanently shut down on 28 June 2010 and has been free of nuclear fuel since end of July 2012, the operator has filed an application for decommissioning on 21 March 2013. Decommissioning is to take place together with the already partially dismantled research reactor Geesthacht-2 (FRG-2) (common reactor pool). On 3 April 2014, the licence for dismantling of the FRM research reactor in Garching was granted. Altogether, eight facilities with a thermal power > 1 MW have been shut down or are in various stages of decommissioning. Several reactors with smaller capacities have permanently been shut down or already been removed. An overview of research reactors permanently shut down or being under decommissioning is given in Annex L-(c) (see Table L-15 and Table L-16).

The amount of spent fuel from research reactors stored as at 31 December 2016 is several orders of magnitude less than the amount to be managed from power reactors. As at 31 December 2016, 41 spent fuel assemblies with approximately 62 kg of heavy metal were stored at the BER II. 40 spent fuel assemblies with around 278 kg of heavy metal and two converter plates with a total of around 0.5 kg of heavy metal were stored at the FRM II in Garching. Four disused fuel assemblies with 764 g of uranium were stored at the TRIGA research reactor Mainz (FRMZ). Approximately 2.3 Mg of spent fuel from the Radiation Protection, Analytics & Disposal Inc. (VKTA) Rossendorf are stored in 18 CASTOR® MTR 2 casks in Ahaus.

All the fuel assemblies from the decommissioned facilities in Geesthacht and Jülich were shipped to the United States of America and the United Kingdom. Fuel assemblies from the BER II have so far been returned to the United States of America. The amendment to the Atomic Energy Act (AtG) according to the Act Amending the Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste and for the Amendment of Other Laws [1A-7b] provides for shipment of fuel assemblies from nuclear fission facilities for research purposes abroad only in exceptional cases. They are stored centrally in Ahaus until disposal. The fuel assemblies of the FRM II are also to be stored in Ahaus. The conversion of the FRM II with regard to the use of fuel with highly enriched uranium (93 % U-235) to lower enrichment is planned. The operator of the BER II, the Helmholtz-Zentrum Berlin, decided in June 2013 to decommission the facility by 1 January 2020. According to current planning, the FRMZ is to be operated at least until 2020.

In the 1960s and 1970s, 12 SURs were installed in the Federal Republic of Germany and, taking these as a model, one training reactor for educational purposes (AKR) in the former German Democratic Republic (GDR). The SURs are so-called zero-power reactors (thermal output 100 mW), which are and were operated with < 20 % enriched uranium dioxide dispersed in polyethylene. An SUR core consists of eight to ten fuel plates. The SURs in Stuttgart, Ulm and Furtwangen as well as the AKR in Dresden are to continue operation.

D.2.2 Activity inventory

The activity inventory of the spent fuel (as at 31 December 2016) at the reactor sites and in the cask storage facilities can be estimated based on the following assumptions:

In an initial approximation, only uranium dioxide fuel is considered. The spent fuel assemblies in the storage facilities are classified according to different age categories. For the spent fuel assemblies unloaded up until 1998, the assumed mean burn-up is 40 GWd/Mg HM, for the years 1999 to 2006 45 GWd/Mg HM, and as from 2007 50 GWd/Mg HM. Furthermore, a minimum decay period of one year for the last unloading is assumed. The underlying data are determined using an internationally recognised burn-up program.

Accordingly, the radioactive inventories as at 31 December 2016 are estimated as follows:

- Inventory of spent fuel stored in NPP fuel pools (corresponding to 3,609 Mg HM) $2.0 \cdot 10^{20}$ Bq
- Spent fuel in casks and storage facilities (corresponding to 4,875 Mg HM) $8.9 \cdot 10^{19}$ Bq

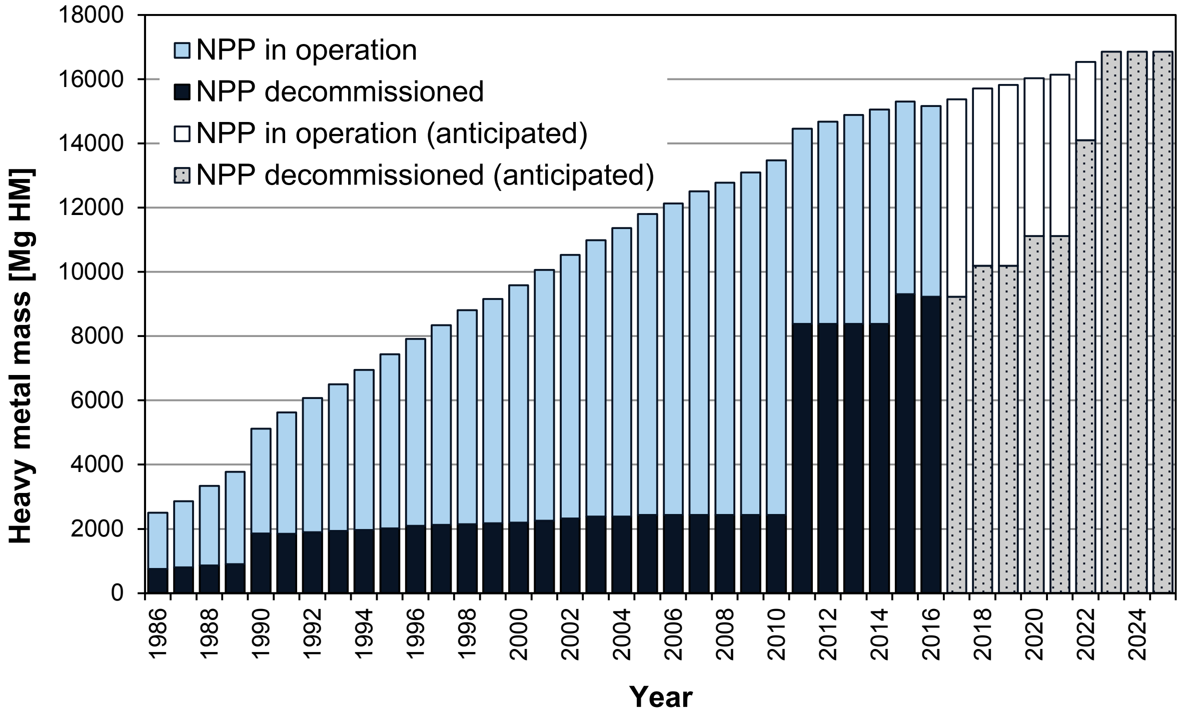
Thus, the total activity of all spent fuel in storage as per the reference date is around $2.9\ 10^{20}$ Bq.

D.2.3 Predicted amounts

The electric power utilities inform the competent supervisory authority about the amounts of spent fuel expected to be produced at each nuclear power plant until their final shutdown at intervals of one year. Under defined boundary conditions of the Thirteenth Act Amending the Atomic Energy Act [1A-25] adopted by the German *Bundestag* on 30 June 2011, it follows that from 1 January 2017 until the permanent shutdown of all plants, about 1,688 Mg HM (including residual cores) of spent fuel will be produced. Together with the spent fuel already produced until 31 December 2016, this amounts to a total of around 16,843 Mg HM, of which around 10,173 Mg HM have to be conditioned and disposed of. The remaining amount was disposed of via other paths, the large majority by reprocessing abroad.

The heavy metal produced over time including the predictions until 2025 is shown in Figure D-7. The graph shows a slight decrease in the amount of heavy metal in 2016 compared to 2015. This is solely due to the calculation method applied and does not mean a reduction in the number of fuel assemblies. The effect can be explained as follows: The quantities underlying the graph are based on data collected annually by the competent supervisory authorities of the *Länder*. In this case, only the number of fuel assemblies at the respective storage locations is queried. The amounts of heavy metal were calculated therefrom by multiplication with the average (fresh) fuel assembly mass. After completion of reprocessing, the *Land* authorities for the first time presented final figures for amounts of heavy metal delivered to France and the United Kingdom, which partly were slightly lower than the amounts calculated since these also included the burn-up. In 2017, the *Land* authorities additionally provided exact figures for the amounts of spent fuel in the on-site storage facilities that were also lower than the amounts previously calculated. This led to the apparent decrease in the accumulated quantities of heavy metal in the graph.

Figure D-7: Accumulated quantities of heavy metal from power reactors by 2025



D.3 Radioactive waste management facilities

D.3.1 Conditioning plants

Due to the operation and decommissioning of nuclear facilities and the use of radioisotopes in research, trade, industry and medicine, radioactive waste is continuously produced in the Federal Republic of Germany, which must be stored until commissioning of a repository. The aim of waste conditioning is therefore to convert radioactive waste through treatment and/or packaging in a form suitable for disposal according to the waste acceptance requirements of the Konrad repository. In order to limit the volumes to be stored and disposed of, conditioning is also aimed at volume reduction. Depending on the composition (organic, metallic, mineral) and state (solid, liquid) of the waste, different conditioning methods are used. Whether solid waste will primarily be burnt, pyrolysed, compacted, melted or crushed and liquid waste primarily dried, cemented or vitrified also depends on the radiological properties of the waste. It may be necessary to use different conditioning methods in consecutive steps before raw waste is processed via one or several intermediates such as to obtain a qualified waste product suitable for disposal.

Conditioning of radioactive waste may take place in mobile or stationary facilities. Frequently used stationary waste conditioning facilities are decontamination and dismantling facilities, drying facilities, evaporator facilities, high-pressure compaction facilities, melting facilities and cementing facilities, which are located, e.g., in Jülich, Karlsruhe, Krefeld and Rubenow near Greifswald and that are also available for the processing of waste from external waste producers. With the gradual shutdown of the German nuclear power plants, the need for stationary conditioning for waste from their operation decreases, while the need for conditioning and storage capacities for waste from decommissioning increases. For example, the GNS Gesellschaft für Nuklear-Service mbH (GNS) will close its Duisburg plant and process orders for stationary conditioning exclusively in its Jülich facility. In Duisburg, GNS has not been receiving radioactive waste for conditioning already since the end of 2016, and it will remove all radioactive substances and all radioactive contamination so that the plant can be used conventionally by the end of 2019 at the latest.

Since the objective is to continuously provide a waste package volume of approximately 10,000 m^3 annually meeting the requirements of the Konrad repository, the conditioning capacities are expanded at some sites. Due to the not yet available facility for disposal, the storage capacities are expanded at various sites (e.g. at Philippsburg, Neckarwestheim, Unterweser and Isar). At the Ahaus cask storage facility, additional storage capacity was created for waste from operation and decommissioning until their delivery to the Konrad repository. Furthermore, the conditioning capacity could be expanded by an extension to the existing Gorleben waste storage facility (ALG). The project is dependent on the date of commissioning of the Konrad repository and is currently being reassessed.

D.3.2 Storage facilities

Until its delivery to a repository, radioactive waste from the operation and decommissioning of nuclear power plants are to be stored in facilities that have to be constructed and operated by the facility operator according to the polluter-pays principle. The Waste Management Transfer Act regulates the transfer of financing responsibility for storage and disposal from the operators to the fund (see details on the Act on the Reorganisation of the Organisational Structure in the Field of Disposal in Chapter E.2.2). Accordingly, the financing obligation of the respective operator shall be transferred to the fund if the operator has provided the payment for the fund intended for this purpose. For the purpose of organising the storage, a publicly owned storage company was founded (Gesellschaft für Zwischenlagerung mbH (BGZ)) to which the storage facilities of the operators will be transferred with effect from 1 January 2019 (storage facilities with a licence according to § 6 of the Atomic Energy Act (AtG) [1A-3]) and with effect from 1 January 2020 (some storage facilities for radioactive waste with negligible heat generation).

In addition to the storage of radioactive waste, decay storage of radioactive residues is also pursued (as regards decay storage, see details in Chapter D.5.6 on the Greifswald nuclear power plant (KGR) and the Rheinsberg nuclear power plant (KKR)) to facilitate processing at a later stage and, where intended, the clearance of the materials and thus to reduce the disposal volume (see Figure D-8).

Figure D-8: Decay storage of large components (steam generator, reactor pressure vessel) at the Zwischenlager Nord (ZLN) (Copyright: EWN)

Apart from the on-site facilities of the nuclear power plants, facilities currently available for waste storage are the Unterweser off-site storage building, the Biblis on-site storage facility (the duration of radioactive waste storage is limited to ten years from the first emplacement of a waste package), the Ahaus transport cask storage facility (TBL-A) (the duration of radioactive waste storage in the western part of the storage hall is limited to ten years from the first emplacement of a waste package), the ALG, the storage building of the power utilities at Mitterteich, the storage facilities of the Daher Nuclear Technologies GmbH (formerly Nuclear + Cargo Service GmbH (NCS)) in Hanau, the Zwischenlager Nord (ZLN), the Rossendorf storage facility (ZLR) as well as the storage capacities of the Kerntechnische Entsorgung Karlsruhe GmbH (KTE). The licences for these storage facilities contain restrictions regarding delivery. For example, only waste from Bavarian nuclear facilities may be delivered to Mitterteich, mainly waste from the Greifswald and Rheinsberg nuclear power plants under decommissioning to the ZLN, and mainly waste from the operation and decommissioning of the facilities at the Karlsruhe site to the KTE for storage. An application was filed for the provision additional storage capacity in the Gorleben transport cask storage facility (TBL-G) for waste meeting the requirements for the Konrad repository. The application documents are under review in the licensing procedure according to § 6 AtG [1A-3] with extension to the handling of other radioactive substances according to § 7 of the Radiation Protection Ordinance (StrlSchV) [1A-8]. Radioactive waste from the reprocessing of German spent fuel abroad is stored at the TBL-G (HLW glass canisters from France) and is intended to be stored in the future at the TBL-A (applied for, CSD-C from France) and at four on-site storage facilities. These are the Philippsburg on-site storage facility (five casks with CSD-B from France) as well as the on-site storage facilities Biblis, Brokdorf and Isar (21 casks with HLW glass canisters from the United Kingdom).

Radioactive waste from large research institutions is generally conditioned and stored at its place of origin. Waste from research, industry and medicine may be delivered to eleven regional *Land* collecting facilities. The waste is accepted for the most part as raw waste. Depending on the availability of technical installations it may be conditioned on site or by external service providers. In addition, there are private conditioning and waste management companies for waste from research, medicine and industry. Waste from the nuclear industry is conditioned on site such to meet the requirements for disposal and delivered to the ALG, the storage building of the power utilities at Mitterteich, or the storage facility of the Daher Nuclear Technologies GmbH in Hanau for storage.

D.3.3 Repositories

All radioactive waste in storage which cannot be cleared by decay storage, is intended for subsequent disposal in deep geological formations.

Morsleben repository for radioactive waste (ERAM)

After the reunification of Germany, the Morsleben repository for radioactive waste (ERAM) in Saxony-Anhalt was taken over by the Federal Office for Radiation Protection (BfS) as the operator (see Figure D-9). With some interruptions, until 1998, it had been used for the emplacement of radioactive waste of nuclear power plants and waste from research, industry and medicine of the German Democratic Republic (GDR) and after takeover by the BfS of waste from the entire Federal Republic of Germany.

After the Higher Administrative Court of the *Land* of Saxony-Anhalt had prohibited further emplacement in the eastern field on 25 September 1998 and after a re-evaluation of safety, the BfS irrevocably waived further emplacement operation in Morsleben in 2001. In 2005, the BfS submitted the documents for public participation in the plan approval procedure for closure of the ERAM to the competent licensing authority of the *Land* of Saxony-Anhalt, the Ministry of Agriculture and the Environment (MLU).

Objections were intensively discussed in a public hearing from 13 to 25 October 2011. The decision on the consideration of objections is made by the MLU within the framework of the plan approval procedure.

The statement [4-11a] of the Nuclear Waste Management Commission (ESK) prepared upon request of the Federal Ministry for the Environment, Nature Conservation, Construction and Nuclear Safety (BMUB) as to whether the long-term safety case for the ERAM developed by the BfS complies with the state of the art in science and technology regarding the methods applied was submitted in January 2013 and contains six recommendations. The implementation of these recommendations requires additional proofs and a revision of the application documents. The necessary work to fulfil these requirements is specified and has been commissioned.

In accordance with the Act on the Reorganisation of the Organisational Structure in the Field of Disposal [1A-30], the operator tasks were transferred to the Bundes-Gesellschaft für Endlagerung mbH (BGE) on 25 April 2017.

Figure D-9: Morsleben repository for radioactive waste (ERAM) (left: aerial view, right: emplacement chamber with stacked low level waste drums) (Copyright: BfS)

Konrad repository

In 1982, the application for a plan approval procedure to use the Konrad mine, a former iron ore mine in Lower Saxony, as a repository for radioactive waste with negligible heat generation was filed. This plan approval procedure for the Konrad repository has been concluded. The plan approval decision was issued on 22 May 2002.

The Konrad repository may only accept radioactive waste with negligible heat generation and a maximum waste package volume of 303,000 m^3.

With its decision of 8 March 2006, the Lüneburg Higher Administrative Court rejected the complaints against the plan approval decision and refused to allow an appeal in front of the Federal Administrative Court (BVerwG). The complaints by the plaintiffs against the non-admission of an appeal were rejected by the Federal Administrative Court on 26 March 2007. There is thus a definitive and incontestable plan approval decision for the Konrad repository.

By letter of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) dated 30 May 2007, the BfS was tasked with retrofitting the Konrad mine to convert it into a repository. The work started in 2007 has been continued.

About 500 ancillary provisions of the plan approval decision have to be observed and already submitted design documents have to be revised for the retrofitting. Due to the advanced time since the plan approval decision was issued, further modification licences concerning conventional building permits also have to be obtained. On 15 January 2008, the main operating plan for the construction of the Konrad repository was approved by the Lower Saxony regional mining, energy and geology authority. The main operating plan allows the necessary mining and construction work to be carried out and is thus an important basis for the conversion of the former iron ore mine into a repository.

The Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH (DBE) commissioned by the Federation to convert the Konrad mine to a repository, communicated the year 2022 to the BfS as the date for commissioning of the Konrad repository. However, the BfS holds the view that the date given by the DBE is subject to uncertainties that, according to the current state, are not quantifiable in detail and also have not been finally evaluated by the Federal Government yet. The BfS requested the DBE to complete construction until September 2022 or, if possible, earlier, and has offered the necessary support to the DBE. In accordance with the Act on the Reorganisation of the Organisational Structure in the Field of Disposal [1A-30], the operator tasks were transferred to the BGE on 25 April 2017.

Approx. 930 million euros were used for the planning and exploration of the repository (1977 – 2007). These costs are not included in the subsequent construction costs. Between 2007 and 2015, approx. 1.06 billion euros actual costs were incurred, taking into account other contractors and the costs of the federal authorities.

In the estimates of the 1980s and 1990s it was assumed that costs of 900 million euros would be incurred for the construction of the Konrad repository from the start of the preparatory work for construction according to the plan approval decision until commissioning. The considerably higher costs of the project cost accounting submitted by the DBE in the meantime compared to prior estimates are particularly due to the changed market situation, the incorporation of the 500 ancillary provisions of the plan approval decision in the planning documents, changes in technical standards (DIN, energy saving regulation), general price, wage and salary increases, and the value added tax increase.

The surface and underground construction measures are progressing (see Figure D-10). The southern winding engine house, the traversable media duct between the southern winding engine house and the switchgear building, parts of media supply and disposal, the weather mast with weather station, the switchgear building, the first construction phase of the reconstruction of the shaft hall including the new construction of the shaft hall extension as well as the materials management building have been completed. The assembly work for the fencing of the two shaft systems K1 and K2 is completed except for a gap in the area of the respective guard houses as scheduled. The administrative and social building is under construction. Furthermore, there has been comprehensive security and corrosion protection work on the shaft head frame.

Outside the premises of Konrad 2, the conversion of district road 39, the access road, the rail connection to the area of the railway siding K2, including track shifting and connecting track, as well as the construction of the rainwater channel between K2 and its entry point into the Beddinger Graben were completed. At the K2 site, the work for the construction of site road "Werkstraße 5" is currently underway. The implementation of compensation and replacement measures has also been started.

The necessary refurbishment of the shafts is being continued. Work on the underground strengthening of galleries and the driving of the infrastructure galleries are currently underway. The six emplacement chambers of storage field 5/1 were driven up to the planned final length. Driving of the return air collection roadway was completed. Driving of the workings for the workshop area and for processing of backfill material is currently underway.

Vehicles for underground work were procured and transported underground. Further, competitive tendering procedures were prepared and tenders invited (partly Europe-wide).

The commissioning work for the southern hoisting system of Konrad 1 has been completed. The northern hoisting system is out of operation and is being dismantled. Transportation of staff and material in Shaft 1 is carried out with the new southern hoisting system.

With the plan approval decision for the Konrad repository of 22 May 2002, the Konrad waste acceptance requirements were laid down as at December 1995, and waste-specific ancillary provisions stipulated in the legislative Part A III and in Annex 4. Thus, the decision to convert the Konrad mine to a repository for radioactive waste with negligible heat generation implies the adaptation and updating of the Konrad waste acceptance requirements. The update of these requirements, which constitute the safety framework for the emplaced waste packages, will take place on a step-by-step basis.

The Konrad waste acceptance requirements are currently available in the version as at December 2014 [BfS 14c].

Figure D-10: Konrad repository construction site in Salzgitter (Copyright: BGE)

D.3.4 Asse II mine

After mining operation from 1909 to 1964, the former potash and rock salt mine Asse II was acquired by the Gesellschaft für Strahlenforschung (GSF), the later Helmholtz Zentrum München (HMGU), on behalf of the Federal Ministry for Scientific Research and Technology (now the Federal Ministry of Education and Research (BMBF)) as a research mine. From 1967 to 1978, radioactive waste had been emplaced in the mine. Parallel to the emplacement, tests with cobalt sources were performed to investigate the impacts of radioactive radiation on salt rock. Until 1995, there was research into the development and demonstration of techniques for the emplacement of radioactive waste.

On 4 September 2008, the then competent BMU, the BMBF and the Lower Saxony Ministry for the Environment, Energy and Climate Protection (NMU) agreed that the Asse II mine in the future is to be treated as a repository according to the AtG. Therefore, the BfS took over the operatorship of the facility on 1 January 2009 from the HMGU. For the operation of the facility, the BfS employed the services of the Asse-GmbH, a 100 % publicly owned company. In accordance with the Act on the Reorganisation of the Organisational Structure in the Field of Disposal [1A-30], the operator tasks were transferred to the BGE on 25 April 2017.

According to the tenth amendment to the AtG of 24 March 2009 [1A-24], operation and closure of the Asse II mine are subject to the requirements pursuant to the AtG. This was preceded by the decision of the Federal Government of 5 November 2008 to transfer the Asse II mine, which had so far been operated according to mining law, to the area of application of nuclear law and to operate the mine in future as a radioactive waste repository according to § 9a AtG [1A-3].

In order to bundle regional interests with regard to a safe closure, already in 2008, the Asse II advisory group (*Asse II-Begleitgruppe*) was established in Wolfenbüttel, which consists of municipal representatives, local politicians, environmental organisations and citizens' initiatives. The working group option – retrieval (AGO), which consists of experts appointed by the Asse II advisory group, gives expert advice to the advisory group.

Since 1988, inflow of groundwater from the overburden into the mine has been observed (see Figure D-11, right). Collecting points were established to collect the influent solutions. A total of about 12 m³ of groundwater saturated with sodium chloride is collected in the mine every day. This salt solution does not come into contact with the emplaced waste. It is not possible to predict the further development of the inflow at this stage.

The current main collecting point is located on the 658 m level. The uncontaminated solution collected here is pumped to the surface. After release from the nuclear and radiation protection law (clearance), the solution had been used for the controlled flooding of an old salt mine until the end of 2016. Since 1 January 2017, another contractor has been using these solutions. In parallel, the BGE is seeking to obtain a water permit for the discharge of uncontaminated, cleared solutions into surface waters.

Figure D-11: Asse II mine (left: waste packages in an emplacement chamber (no more accessible today), right: dripping point) (Copyright: BfS)

For stabilisation of the mine, former mining chambers in the southern flank were backfilled with fine-grained crushed salt from August 1995 to December 2003. Subsequent to it, backfilling of shafts and drifts below the emplacement areas with rock salt and magnesium chloride solution started. The rates of deformation of the remaining strongholds are still high. Therefore, after having taken over the operatorship, the BfS carried out further stabilisation measures with Sorel concrete to improve stability and precautionary measures regarding the influent solutions. Emplacement chambers were not backfilled. Backfilling of the emplacement chambers is only provided for the occurrence of an emergency (e.g. in case of a solution inflow found to be uncontrollable).

Moreover, for the case of a beyond-design solution inflow, emergency planning was set up describing further emergency preparedness and response measures (e.g. expansion of the capacity for solution management or preparatory planning for evacuation, remaining backfill, shaft seals and controlled cross-flooding).

With public participation and the involvement of various experts and the AGO a comparison of options was performed in 2009 to identify the safest closure strategy for the Asse II mine. Three possible closure options (retrieval, relocation and complete backfilling of the mine) were described, analysed and evaluated.

As a result of the comparison, the then competent BfS identified the retrieval of all waste as the closure option by which long-term safety can be demonstrated with the highest probability through the controlled disposal of the waste in a plan-approved repository. The retrieval of all waste was therefore considered the preferred method for the closure of the Asse II mine.

On 28 February 2013, the German *Bundestag* adopted the Act on Speeding up the Retrieval of Radioactive Waste and the Closure of the Asse II Mine (“Lex Asse”) [1A-26], which governs the closure of the Asse II mine following the retrieval of the radioactive waste and entered into force in April 2013.

Due to the limited knowledge about the condition of the waste and the emplacement chambers, the realisation of retrieval is fraught with uncertainties. For this reason, first of all a fact finding and trial phase will take place, which originally was planned to be divided into three steps:

- In a first step, there will be drillings into two emplacement chambers at the 750 m level to take gaseous, liquid and solid samples and for explorations of the surrounding area of the emplacement chambers.
- In a second step, these emplacement chambers were to be opened to assess their condition and the condition of the emplaced packages.
- Only then, in a third step, it was intended to recover first waste packages from the two emplacement chamber by way of trial.

On 21 April 2011, the NMU granted a licence according to § 9(1) AtG for the first step of fact finding, i.e. drilling into the emplacement chamber 7 and 12 at the 750 m level. The first drilling started on 1 June 2012, had a total length of 35 m and was above emplacement chamber 7/750 in the salt rock. To explore the chamber ceiling and possible cavities at the upper edge of the emplacement chamber, radar measurements were conducted from the borehole. Subsequently, the borehole was backfilled. A second borehole was drilled west to the sealing structure into emplacement chamber 7/750. At the beginning of June 2013, it reached a waste package at a depth of 23.20 m. First results were obtained on the radiological situation in the backfill material and its pore volume. Flammable or explosive gas mixtures were not found. In the meantime, there have been four further drillings into the stope above the emplacement chamber with a maximum length of 58 m. An important result was that the condition of the stope above emplacement chamber 7/750 is worse than expected. Further knowledge was gained on the geometry of the emplacement chamber. The occurrence of explosive gases is far below the explosion limit so far, the radiological findings are in the expected range.

The fact finding will take longer than planned. Contrary to initial expectations (three years), it is assumed today that it will take about eight to ten years.

The longer the mine will be kept open, the higher is the risk that the inflow of groundwater will shift to inaccessible areas and can no longer be collected there or increases. With the "Lex Asse", the procedural framework conditions have been created for speeding up the work. Accordingly, justifications with respect to individual measures or closure variants are no longer required. Against this background, fact finding and the procedure for retrieval so far were evaluated.

As a result, retrieval is to begin from the emplacement chambers for which atmosphere and local rock conditions are known. The experience gained can then be used for retrieval from sealed and completely backfilled emplacement chambers, and opening and recovery on a trial basis are dispensed with (steps 2 and 3 of the initially planned fact finding). The currently ongoing first step of fact finding (drilling into chambers) is to be completed by the end of 2017 for emplacement chamber 7/750 as scheduled. The further procedure for drilling into emplacement chamber 12/750 is currently being decided.

A working group of the BfS had started work on the conceptual planning of an early retrieval from the open emplacement chamber 7/725. Planning work for the retrieval of intermediate level waste from the 511 m level was put out to tender in summer 2016. Since the beginning of 2015, the working group “Konzeptplanung Rückholung“ (Arge KR) has been commissioned with the conceptual planning of the retrieval of radioactive waste from the 750 m level. The new operator BGE is continuing this work.

Already during a workshop for the evaluation of retrieval in January 2012 it was stated that a new shaft for recovery of the waste is urgently required. The creation of new underground infrastructure rooms outside the current mine workings (galleries for recovery with auxiliary ventilation, locks, buffer storage, etc.) is obligatory. Prior to the start of retrieval, emergency preparedness measures (particularly stabilisation and backfilling) need to be fully implemented.

In addition, a storage facility and the necessary infrastructure must be completed. Appropriate recovery technology must be identified or, in part, still be developed.

The salt structure is currently being explored with regard to the underground infrastructure rooms and the planned emplacement areas of a new shaft site. Four drillings to explore the shaft site, an exploration drilling at the surface to a depth of 900 m, two underground drillings at the 574 m level (370 m and 293 m borehole length) and one at the 700 m level (254 m) have been completed so far. Another drilling was carried out at the 574 m level to explore the northern flank of the salt structure to a depth of 256 m. Further drillings at the 700 m level are currently being planned to explore suitable salt formations for the underground infrastructure areas. A decision on the suitability of the currently planned shaft site will only be possible after completion of the explorations and evaluation of the results.

Due to the evaluation of the fact finding, the procedure will change until the start of retrieval (omission of steps 2 and 3 of the fact finding, early retrieval from the emplacement chamber 7/725). A thorough revision of the framework schedule is therefore necessary. This was noted directly after the decision on the changed procedure and has not been completed yet.

Acceleration potential exists, in particular, for the subprojects whose completion is a prerequisite for retrieval (construction of shaft 5, planning and construction of the storage facility and development of recovery techniques).

For the case of beyond-design solution inflow before retrieval of the waste and that waste or parts of it remain in the mine, the BGE carries out consequence analyses which are intended to assess the radiological consequences. The development of calculation models requires, e.g., more detailed knowledge of the geological conditions. For further exploration of the overburden in the area of the southern flank, various investigations are provided.

The Commission on Radiological Protection (SSK) points out that at present, a reliable forecast of the radiation exposure of the personnel and the public occurring during retrieval of the waste from the Asse II mine cannot be made. During retrieval of the waste, additional radiation exposure for the operating personnel and the public would have to be accepted over the next decades. The conservatively calculated potential future doses in the case that the waste remains in the Asse II mine must be weighed against this.

D.4 Inventory of radioactive waste

In the Federal Republic of Germany, radioactive waste originates from

- the operation of nuclear power plants and research reactors,
- the decommissioning of nuclear power plants, of experimental and demonstration reactors, as well as from research and training reactors for educational purposes, and other nuclear facilities,
- uranium enrichment and fuel fabrication (nuclear industry),
- basic and applied research,
- the use of radioisotopes in other research institutions, universities, trade and industry companies, hospitals and medical practices,
- other waste producers, such as the military sector,
- the future conditioning of spent fuel intended for direct disposal.

According to contractual agreements with the reprocessing companies in France and the United Kingdom, Germany must accept the return of an equivalent amount of radioactive waste obtained from the reprocessing of spent fuel from light water reactors. The return of the vitrified fission product concentrate from France started in May 1996 and was completed in November 2011 as scheduled. For the other radioactive waste to be returned from the United Kingdom and France, plans have been prepared.

In the following, an overview is given of the inventory of untreated radioactive residues, together with the inventory of intermediate waste products and conditioned waste as at 31 December 2016 as well as a forecast of the volume of waste expected to arise until the year 2080. An overview of the radioactive waste disposed of in the Morsleben repository for radioactive waste (ERAM) and the waste emplaced in the Asse II mine is also provided.

D.4.1 Inventory of radioactive waste and forecast

The inventory of radioactive waste is determined for radioactive waste with negligible heat generation as well as for heat-generating radioactive waste.

Radioactive waste with negligible heat generation

According to its state of processing, the waste is divided into raw waste (RA), i.e. waste in its original form and pretreated waste (VA) which, e.g., has undergone preconditioning for better handling. For storage, waste will generally be conditioned. The conditioning process generates waste products that are usually stored in drums which are an inner container (P1) or have already been inserted into Konrad containers (G1). If further treatment of the waste product before disposal is not intended, it can be determined through the product control carried out by the Bundes-Gesellschaft für Endlagerung mbH (BGE) that the waste product is suitable for the Konrad repository if it meets the waste acceptance requirements. In this way, a product-controlled waste product (P2) is generated from the waste product of the P1 category. The waste products of the P2 category will then be inserted into Konrad containers (G1) for disposal. If suitability of the waste package (G1) for disposal is confirmed by the BGE, it will be categorised as product-controlled waste package (G2) and can be disposed of on call by the repository.

Table D-5: Overview of masses and volumes of radioactive waste in storage facilities with negligible heat generation as at 31 December 2016

Waste category	Unit	Konrad repository	Other repository
RA – raw waste	[Mg]	5,322	2,336
VA – pretreated waste	[Mg]	11,125	2,216
P1 – waste in inner containers	[m³]	14,523	144
P2 – product-controlled waste products	[m³]	2,439	0
G1 – waste in Konrad containers	[m³]	100,279	1
G2 – product-controlled waste packages	[m³]	2,936	0
Total	**[Mg]**	**16,447**	**4,552**
	[m³]	**120,177**	**145**

According to Table D-5, the raw and pretreated waste stored at the waste producers' sites amounted to 20,999 Mg. 17,106 m^3 of the 120,323 m^3 of waste stored in containers (gross volume) relate to waste in inner containers that still have to be packed in Konrad containers and 103,216 m^3 to waste already packed in Konrad containers. As at 31 December 2016, 2,936 m^3 of waste have been prepared for delivery to the Konrad repository. Only a small amount of radioactive waste with negligible heat generation which does not comply with the Konrad waste acceptance requirements [BfS 14c] or for which decay storage with subsequent conditioning is intended after Konrad's expected end of operation must be stored in a facility for disposal according to the Repository Site Selection Act (StandAG) [1A-7a].

Table D-6 shows the inventory of radioactive waste with negligible heat generation for the different groups of waste producers.

Table D-6: Overview of the inventory of radioactive waste with negligible heat generation according to its state of processing as at 31 December 2016

Waste producer groups	RA Mass [Mg]	VA Mass [Mg]	P1 Volume [m³]	P2 Volume [m³]	G1 Volume [m³]	G2 Volume [m³]
Research institutions	1,574	5,802	1,944	49	41,834	0
Nuclear industry	196	15	330	101	7,475	2,921
Nuclear power plants*	5,113	6,792	9,522	2,222	35,135	15
Land collecting facilities	590	516	2,360	67	957	0
Reprocessing (WAK)	187	216	511	0	14,879	0
Total	**7,658**	**13,341**	**14,667**	**2,439**	**100,280**	**2,936**

* Nuclear power plants in operation, permanently shut down, under decommissioning and dismantled nuclear power plants

Table D-7 gives an overview of the distribution of the inventory of conditioned radioactive waste with negligible heat generation to the different storage facilities.

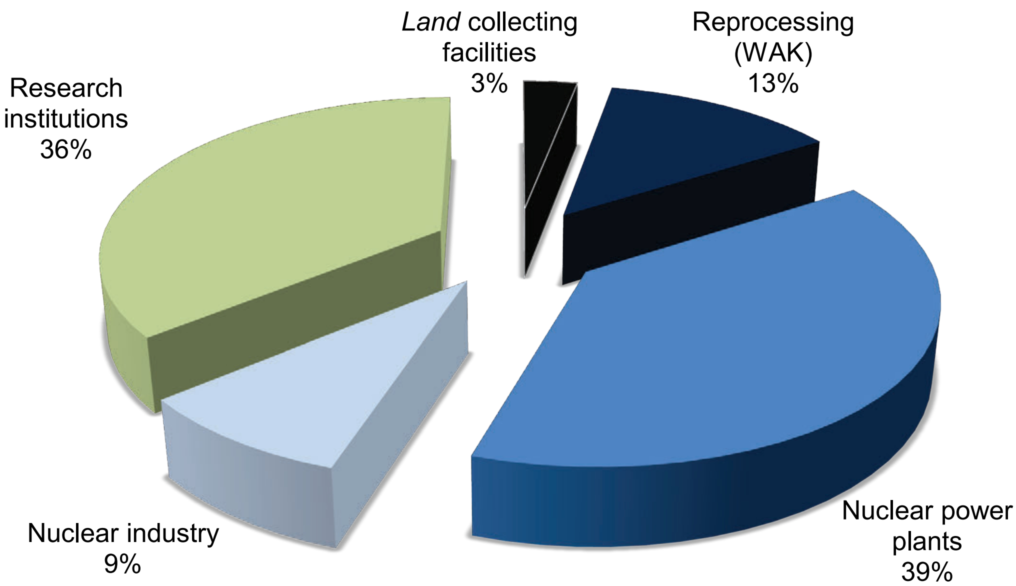
Table D-7: Storage of radioactive waste with negligible heat generation of categories P1 to G2 as at 31 December 2016

Storage facility	Waste volume [m³]
Research centres, including customers	61,965
Nuclear industry	2,540
ZLN storage facility	6,830
Nuclear power plants	14,631
Land collecting facilities	1,108
Storage facility Unterweser	1,422
Storage facility of the utilities at Mitterteich (GRB)	8,200
GNS Werk Gorleben	6,979
Daher Nuclear Technologies (former NCS)	7,684
GNS and other storage facilities	2,936
Central storage facility in the Ahaus transport cask storage facility	1,633
Storage facility of the Stade nuclear power plant	4,403
Research centres, including customers	61,965

* Deviation due to rounding

Figure D-12 shows the distribution of the radioactive waste inventory with negligible heat generation accumulated by the end of 2016 to the different waste producers.

Figure D-12: Distribution of the radioactive waste inventory with negligible heat generation of categories P1 to G2 according to waste producer groups as at 31 December 2016



Heat-generating radioactive waste

As at 31 December 2016, 577 m³ of heat-generating radioactive waste were stored in the Federal Republic of Germany in addition to spent fuel. The major part of the conditioned heat-generating radioactive waste originates from reprocessing. The conditioned waste from reprocessing is contained in 108 casks (one cask of the TS 28 V type, 74 casks of the CASTOR® HAW 20/28 CG type, 21 casks of the CASTOR® HAW 28M type, 12 casks of the TN85 type) holding a total of 3,024 canisters with vitrified fission product concentrate from the reprocessing of spent fuel at AREVA-NC. In the years 2009 and 2010, the liquid fission product concentrate was vitrified in the Karlsruhe vitrification plant (VEK). Since February 2011, the vitrified waste produced thereby has been stored in five transport and storage casks of the CASTOR® HAW 20/28 CG type at the Zwischenlager Nord (ZLN). The other heat-generating radioactive waste generally consists of activated components and spent fuel parts from the Karlsruhe reprocessing plant (WAK), concentrate and unsorted waste, e.g. from the dismantling of the WAK and the compact sodium-cooled nuclear reactor plant II (KNK II). The distribution of the inventory of heat-generating radioactive waste is shown in Table D-8.

Table D-8: Overview of the inventory of heat-generating radioactive waste as at 31 December 2016

Waste producer groups	Waste [m³]
Research institutions	5
Nuclear industry	0
Nuclear power plants	0
Decommissioned nuclear power plants	0
Land collecting facilities	2
Others	0
Reprocessing (WAK and abroad)	570
Total	**577**

The conditioned radioactive waste, both the waste with negligible heat generation and heat-generating radioactive waste, is stored at the waste producers' facilities, as well as in on-site and central storage facilities.

Deviations of the inventory of heat-generating radioactive waste from the previous report are due to the changed classification in the inventory query on radioactive waste with negligible heat generation for a repository according to the StandAG.

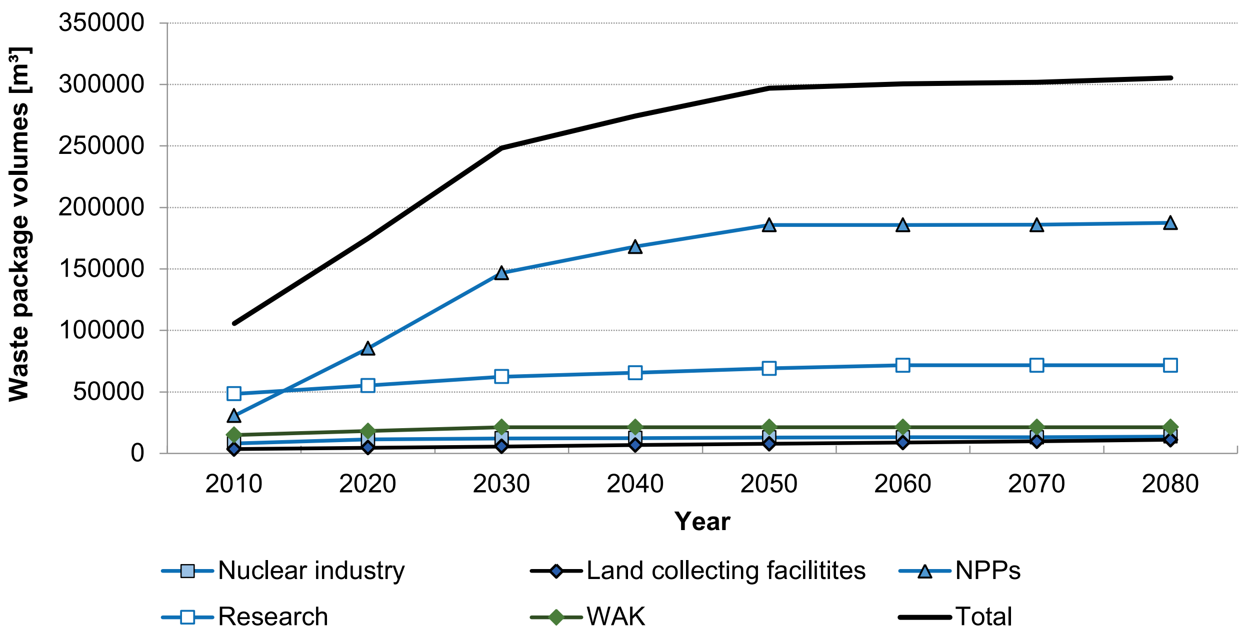
Forecasts

Regarding the work involved in planning a facility for disposal, it is necessary to make forecasts on the waste produced in future and to update these when boundary conditions change. The waste producers provided information about the expected waste volumes. This information also comprises the respective waste volumes expected in connection with the decommissioning and dismantling of nuclear facilities. The data provided represent planning values that are subject to uncertainties and which will have to be reviewed and adapted in the future.

For the forecast of the volumes of radioactive waste with negligible heat generation, the following boundary conditions were assumed: For each nuclear power plant unit, the operational waste is assumed to amount to a waste package volume of 45 m³ (conditioned waste) per year. During a transitional phase of four years from operation until decommissioning, the licensing procedure for decommissioning is performed. During this period, further operational waste is produced. For the decommissioning itself, an average of about 5,000 m^3 per light water reactor has been considered. The amount of decommissioning waste arising depends on when the decommissioning licence was granted and on the decommissioning concept (immediate dismantling or dismantling after a period of safe enclosure). It is expected that the volume of decommissioning waste will be reduced further due to the progressing improvement of methods applied. Furthermore, it has to be taken into account that great efforts are undertaken to clear materials for release and that mainly only those materials will be counted among the radioactive waste which even after a longer decay period cannot be cleared (e.g. active components that used to be close to the core). It is expected that the largest waste stream volume will come from the decommissioning of the nuclear power plants.

The time-dependent accumulation of waste expected by the waste producers is modelled in Figure D-13 which shows that large amounts of waste are not to be expected after 2040.

Figure D-13: Time-dependent accumulation of radioactive waste with negligible heat generation as waste package volumes until 2080



The accumulated inventory of heat-generating radioactive waste in the year 2080 is estimated under the boundary conditions of the Thirteenth Act Amending the Atomic Energy Act [1A-25] adopted by the German *Bundestag* on 30 June 2011, taking the residual operating times into account. A volume of around 27,000 m^3 is obtained for the following cask concept developed for disposal in a salt dome:

- approx. 20,400 m^3 of packaged fuel from light water reactors for direct disposal (this estimate is based on the assumption of disposal in POLLUX casks as present reference concept; 10,173 Mg HM),
- approx. 700 m^3 of vitrified waste in canisters (HLW from France, the United Kingdom and Karlsruhe as well as vitrified waste from liquid waste processing at the French La Hague reprocessing plant),
- approx. 740 m^3 of structural parts and sleeves (CSD-C) in canisters from reprocessing of spent fuel in reprocessing plants abroad (France),

- approx. 1,340 m³ packaged fuel from the Hamm-Uentrop thorium high-temperature reactor (THTR),
- approx. 195 m³ of packaged fuel from the Radiation Protection, Analytics & Disposal Inc. (VKTA), and the research reactors still in operation, and
- approx. 3,400 m³ of waste packages with structural parts of the spent fuel for direct disposal.

D.4.2 Inventory of the Morsleben repository for radioactive waste

During the period from 1971 to 1991 and from 1994 to 1998, low and intermediate level radioactive waste with comparatively low concentrations of alpha sources was emplaced in the ERAM.

This waste originated from

- the operation of nuclear power plants,
- the decommissioning of nuclear facilities,
- the nuclear industry,
- research institutions,
- *Land* collecting facilities or directly from small waste producers, and
- the handling by other users.

In addition, radioactive waste is still disposed of which is generated by the operation of the ERAM to keep the mine open and whose activity has already been taken into account in the overall activity of the radioactive waste delivered. As at 31 December 2016, a total of 37,158 m³ of solid and solidified waste and 6,621 sealed radioactive sources were disposed of, including the radioactive waste from operation to keep the mine open. In general, the emplaced radioactive waste is packaged in standardised containers, such as 200 to 570 l drums and cylindrical concrete containers. The sealed radioactive sources are not subjected to further treatment or only packaged in small containers. In addition to the radioactive waste disposed of, sealed cobalt radioactive sources, some caesium radioactive sources, and small quantities of solid intermediate level radioactive waste (europium waste) in seven special containers (steel cylinders) with a volume of 4 l each and one 280 l drum containing Ra-226 waste with an activity of approx. $1.4 \cdot 10^{14}$ Bq (as at 31 December 2016) are in storage. Within the scope of the plan approval procedure for the closure, an application was submitted to dispose of this waste currently in storage.

Building rubble, contaminated soil, cemented mixed waste both compacted and uncompacted, metallic waste, combustion residues, contaminated laboratory waste, cemented rinse solutions and immobilised radiation sources were supplied to the ERAM as radioactive waste by research institutions and other waste producers. Most of the radioactive waste from these waste producers is packaged in 200 l drums.

Waste data on the emplaced radioactive waste are documented and archived. The total activity of all emplaced radioactive waste is in the order of magnitude of 10^{14} Bq, the activity of the alpha sources about 10^{11} Bq. Table D-9 provides an overview of the activity of the relevant radionuclides contained in the waste disposed of in the ERAM. The activity data refer to 31 December 2016.

Table D-9: Radionuclide-specific activities of the waste disposed of in the ERAM as at 31 December 2016

Alpha sources	Activity [Bq]
Am-241	$2.3 \cdot 10^{11}$
Am-243	$9.5 \cdot 10^{07}$
Cf-249	$5.8 \cdot 10^{05}$
Cf-251	$2.3 \cdot 10^{04}$
Cf-252	$4.2 \cdot 10^{03}$
Cm-243	$5.5 \cdot 10^{05}$
Cm-244	$4.3 \cdot 10^{09}$
Cm-245	$2.3 \cdot 10^{06}$
Cm-246	$2.6 \cdot 10^{06}$
Cm-247	$2.6 \cdot 10^{04}$
Cm-248	$2.2 \cdot 10^{07}$
Cm-250	$3.3 \cdot 10^{02}$
Np-237	$8.3 \cdot 10^{07}$
Pa-231	$1.7 \cdot 10^{06}$
Pu-238	$7.8 \cdot 10^{10}$
Pu-239	$6.8 \cdot 10^{10}$
Pu-240	$6.6 \cdot 10^{10}$
Pu-242	$9.9 \cdot 10^{07}$
Pu-244	$2.1 \cdot 10^{04}$
Ra-224	$4.1 \cdot 10^{08}$
Ra-226	$2.3 \cdot 10^{10}$
Th-228	$4.1 \cdot 10^{08}$
Th-229	$4.6 \cdot 10^{05}$
Th-230	$1.9 \cdot 10^{06}$
Th-232	$5.8 \cdot 10^{06}$
U-232	$4.3 \cdot 10^{07}$
U-233	$5.0 \cdot 10^{06}$
U-234	$1.1 \cdot 10^{09}$
U-235	$8.2 \cdot 10^{07}$
U-236	$4.8 \cdot 10^{07}$
U-238	$4.3 \cdot 10^{08}$

Beta/Gamma sources	Activity [Bq]
Ac-227	$5.8 \cdot 10^{06}$
Ac-228	$2.6 \cdot 10^{08}$
Ag-108m	$6.4 \cdot 10^{10}$
Al-26	$8.6 \cdot 10^{05}$
Am-242m	$2.3 \cdot 10^{08}$
C-14	$3.2 \cdot 10^{12}$
Ca-41	$7.3 \cdot 10^{07}$
Cd-113m	$5.7 \cdot 10^{09}$
Cl-36	$3.9 \cdot 10^{09}$
Co-60	$3.6 \cdot 10^{12}$
Cs-134	$3.4 \cdot 10^{09}$
Cs-135	$3.7 \cdot 10^{08}$
Cs-137	$5.9 \cdot 10^{13}$
Eu-152	$1.8 \cdot 10^{11}$
Eu-154	$1.5 \cdot 10^{11}$
Eu-155	$1.4 \cdot 10^{10}$
Fe-55	$6.6 \cdot 10^{10}$
H-3	$1.7 \cdot 10^{12}$
Ho-166m	$3.3 \cdot 10^{04}$
I-129	$2.1 \cdot 10^{08}$
K-40	$2.3 \cdot 10^{10}$
Kr-85	$1.7 \cdot 10^{11}$
Mn-54	$9.4 \cdot 10^{03}$
Mo-93	$2.5 \cdot 10^{08}$
Na-22	$1.4 \cdot 10^{08}$
Nb-94	$2.7 \cdot 10^{10}$
Ni-59	$1.8 \cdot 10^{11}$
Ni-63	$1.4 \cdot 10^{13}$
Np-236	$4.5 \cdot 10^{03}$
Pb-210	$1.3 \cdot 10^{10}$
Pd-107	$6.7 \cdot 10^{07}$
Pm-147	$4.8 \cdot 10^{09}$
Pu-241	$7.7 \cdot 10^{11}$
Ra-228	$2.6 \cdot 10^{08}$
Rb-87	$2.8 \cdot 10^{07}$
Ru-106	$9.1 \cdot 10^{05}$
Sb-125	$4.0 \cdot 10^{09}$
Se-79	$1.9 \cdot 10^{08}$
Sm-151	$2.5 \cdot 10^{11}$
Sn-126	$2.4 \cdot 10^{08}$
Sr-90	$4.4 \cdot 10^{12}$
Tc-99	$1.0 \cdot 10^{11}$
Zr-93	$9.3 \cdot 10^{09}$

The major part (about 90 %) of the emplaced waste volume originates from nuclear power plants in operation and decommissioned nuclear power plants. The remaining 10 % comes from research, industry, business, medicine and other delivering parties. As the limit for the activity of alpha sources was very low at ERAM ($4 \cdot 10^8$ Bq/m³), the volume of the waste originating from the nuclear industry, research centres and the WAK is low. Table D-10 shows the volume of waste emplaced in the ERAM, classified according to individual waste producer groups.

Table D-10: Volume emplaced in the ERAM according to individual waste producer groups as at 31 December 2016

Waste producer groups	Volume [m³]
Nuclear power plants	23,816
Decommissioned nuclear power plants	6,528
Research	2,592
Nuclear industry	159
Land collecting facilities	3,090
Others	901
Karlsruhe reprocessing plant (WAK)	45
Total	**37,131**

D.4.3 Inventory of the Asse II mine

The data on the inventory of the Asse II mine originate from a waste database established by the former operator Gesellschaft für Strahlenforschung (GSF, later Helmholtz Zentrum München (HMGU)) in 2000. This waste database was last revised in 2010 to check the inventory (ASSEKAT Version 9.2).

The Federal Office for Radiation Protection (BfS) had prompted a review of the waste database according to which comprehensive recommendations were made. Some of them refer to the raw data and some to the calculation modules of the waste database which are used to determine the inventories on a specific date. The following inventory data are based on the revised version of the waste database and are subject to the reservation that most of the recommendations have not been implemented yet. The revision of the calculation module is very complex and not yet completed. The inventory data will therefore still be subject to changes in the future.

In the Asse II mine, emplacement of low level radioactive waste, which was handled without additional shielding, began in 1967, the emplacement of intermediate level radioactive waste in 1972. For transport and storage of intermediate level radioactive waste, an additional shielded cask was needed. In 1978, the limited emplacement licences expired. Until then, about 47,000 m³ of radioactive waste (package gross volume) from the delivering parties had been emplaced in various waste package types:

- 124,494 packages as low level radioactive waste with a total activity of about $1.84 \cdot 10^{15}$ Bq (as at 31 December 2016). According to the current state of knowledge, 14,779 of them are so-called lost concrete shieldings (VBA) containing waste with higher activity. Altogether, the packages contain about 80 % of the total activity in the Asse II mine and are distributed over eleven chambers at the 750 m level and one chamber at the 725 m level.
- 1,293 drums holding intermediate level radioactive waste with a total activity of about $4.79 \cdot 10^{14}$ Bq (as at 31 December 2016). These are about 20 % of the total activity and are stored at the 511 m level. Additionally, eight drums with low level radioactive waste are also stored there. The latter was emplaced for testing of a new shielded cask (E2).

Table D-11 gives an overview of waste origin and the percentages of the total activity.

Table D-11: Percentages of the waste packages emplaced in the Asse II mine with regard to waste origin, number and activity

Delivering party (waste origin)	Waste packages [%]	Total activity [%]
Kernforschungszentrum Karlsruhe (KfK), transferred to KTE Kerntechnische Entsorgung Karlsruhe GmbH (KTE)	49	93
Kernforschungsanlage Jülich (KFA), transferred to Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH (JEN)	10	1
Nuclear power plants	25	2
Other delivering parties	16	4
Total	**100**	**100**

The low level radioactive waste was mainly emplaced in drums with volumes of between 200 and 400 l or in cylindrical concrete containers. For the emplacement of intermediate level waste, only 200 l drums were used.

The low level radioactive waste emplaced contains solidified or dried, former aqueous waste, such as evaporator concentrates, filter residues, sludges, ion exchanger resins, furthermore solid waste such as scrap, rubble and mixed waste. As regards the intermediate level radioactive waste, metal scrap, filters and solidified former aqueous waste was emplaced. The percentages of the waste packages (number of packages) emplaced with regard to the different types of waste are given in Table D-12 for low level waste (LLW) and intermediate level waste (ILW). According to the current state of knowledge, no high level radioactive waste was emplaced in the Asse II mine. Eight drums filled with intermediate level radioactive waste from the former Kernforschungsanlage Jülich (KFA) (now Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH, JEN) contain parts of fresh fuel rod segments or irradiated for a short time, or AVR fuel spheres with, in some cases, enriched uranium.

Table D-12: Percentages of the waste packages with regard to the different types of waste for LLW und ILW

Type of waste	LLW packages [%]	ILW packages [%]
Filter, filter aids, sludges, evaporator concentrates, resins, etc.	30	35
Metal scrap (iron, steel metal, structural parts, pipes, etc.)	20	65
Rubble, gravel, floor coverings, etc.	10	-
Mixed waste, paper, film, overalls, galoshes, cleaning rags, wood, glass, etc.	40	-
Total	**100**	**100**

The 125,787 waste packages emplaced, which have a gross waste package volume of about 47,000 m³ and a total mass of about 89,000 Mg, had a total activity of about $1 \cdot 10^{16}$ Bq at the time of emplacement. Table D-13 gives an overview of the activities of the relevant radionuclides in the waste emplaced in the Asse II mine as at 31 December 2016. At that time, the total activity was about $2.3 \cdot 10^{15}$ Bq, including an alpha activity of about $4.0 \cdot 10^{14}$ Bq.

Table D-13: Activity inventory of relevant radionuclides in the Asse II mine as at 31 December 2016

Radionuclide	Activity [Bq]	Radionuclide	Activity [Bq]
H-3	$3.6 \cdot 10^{11}$	Ra-226	$2.0 \cdot 10^{11}$
C-14	$2.6 \cdot 10^{12}$	Th-232	$3.3 \cdot 10^{11}$
Cl-36	$7.2 \cdot 10^{09}$	U-234	$1.4 \cdot 10^{12}$
Co-60	$7.5 \cdot 10^{12}$	U-235	$5.3 \cdot 10^{10}$
Ni-59	$1.8 \cdot 10^{12}$	U-236	$2.4 \cdot 10^{10}$
Ni-63	$2.5 \cdot 10^{14}$	U-238	$1.3 \cdot 10^{12}$
Se-79	$3.4 \cdot 10^{09}$	Np-237	$3.9 \cdot 10^{09}$
Sr-90	$1.8 \cdot 10^{14}$	Pu-239	$4.4 \cdot 10^{13}$
Zr-93	$5.5 \cdot 10^{11}$	Pu-240	$4.9 \cdot 10^{13}$
Nb-94	$1.8 \cdot 10^{11}$	Pu-241	$1.1 \cdot 10^{15}$
Tc-99	$1.1 \cdot 10^{11}$	Pu-242	$9.0 \cdot 10^{10}$
Sn-126	$4.6 \cdot 10^{09}$	Am-241	$2.4 \cdot 10^{14}$
I-129	$2.7 \cdot 10^{08}$	Cm-244	$7.1 \cdot 10^{11}$
Cs-135	$3.2 \cdot 10^{09}$	Cm-245	$2.7 \cdot 10^{08}$
Cs-137	$3.3 \cdot 10^{14}$	Cm-246	$3.3 \cdot 10^{08}$
Sm-151	$3.3 \cdot 10^{12}$		

D.4.4 Inventory from past practices

Waste from past practices has been conditioned and either stored (see reporting on Article 32(2)(iv)(a)) or was disposed of (see reporting on Article 32(2)(iv)(b)).

Reporting on measures related to former practices is contained in Chapter H.2.2.

D.5 List of decommissioned facilities

D.5.1 Overview

As part of this report for the Joint Convention, an overview is given of nuclear facilities in Germany that have been permanently shut down and of nuclear facilities being under decommissioning (nuclear power plants, experimental and demonstration reactors, research reactors, nuclear fuel cycle facilities). In Germany, a nuclear facility is regarded as being “under decommissioning” only if a decommissioning licence was granted. The report also includes information on the status of decommissioning of nuclear facilities. Table D-14 gives an overview of the number of nuclear facilities permanently shut down, being under decommissioning and those for which decommissioning has been completed and which were released from regulatory control. Plant-specific lists can be found in Table L-14 to Table L-19 in Annex L-(c).

The use of nuclear energy for the commercial electricity production is phased out in Germany step by step. The last nuclear power plant is to be shut down in 2022. The end of the operating lifetimes of the individual nuclear power plants is defined in the Atomic Energy Act (AtG) [1A-3]. The final shutdown of a nuclear power plant is followed by the post-operational phase (operating phase after expiry of the authorisation for power operation until granting of the decommissioning licence). In the post-operational phase, preparatory work for decommissioning can be carried out. Wide experience has already been gained in Germany with the decommissioning of nuclear facilities over the past four decades. Many research reactors and all experimental and demonstration reactors but also some larger nuclear power plants as well as nuclear fuel cycle facilities are in various stages of decommissioning. Some of the decommissioned facilities have meanwhile been completely removed and the sites are being reused.

Table D-14: Overview of nuclear facilities permanently shut down, being under decommissioning and those for which decommissioning has been completed

Type of facility	Permanently shut down	Under decommissioning	Decommissioning completed
Power reactors	4 reactors	17 reactors	-
Experimental and demonstration reactors	-	4 reactors (see explanation in D.5.3)	3 reactors and the nuclear ship Otto Hahn
Research reactors ≥ 1 MW thermal power	2 reactors	6 reactors (see explanation in D.5.4)	1 reactor
Research reactors < 1 MW thermal power	2 reactors	-	26 reactors 1 reactor rededicated
Nuclear fuel cycle facilities (primarily commercial fuel fabrication and reprocessing)	-	1 facility	5 facilities
Research, experimental and demonstration facilities of the nuclear fuel cycle	-	-	3 facilities

D.5.2 Power reactors

With the entry into force of the Thirteenth Act Amending the Atomic Energy Act [1A-25] on 6 August 2011 as a result of the events in Japan, the authorisation for power operation for the eight nuclear power plants Biblis Unit A and Unit B, Neckarwestheim I, Brunsbüttel, Isar 1, Unterweser, Philippsburg 1 and Krümmel expired. The operator of the Grafenrheinfeld nuclear power plant (KKG) had already announced in 2014 to take the KKG out of operation prior to the date specified. According to the AtG, the authorisation for power operation would have been expired on 31 December 2015. On 27 June 2015, the KKG has been finally taken off the grid. For all these nuclear power plants, first decommissioning and dismantling licences have been applied for pursuant to § 7(3) AtG. So far, licences were granted for the nuclear power plants Isar 1 (on 17 January 2017), Neckarwestheim I (on 3 February 2017), Biblis Unit A and Unit B (on 30 March 2017), and Philippsburg 1 (on 7 April 2017).

After the entry into force of the Act on the Reorganisation of Responsibility in Nuclear Waste Management on 16 June 2017 with the amendments to the Atomic Energy Act contained therein, these power plants are immediately to be shut down and dismantled. Thus, the option of safe enclosure is no longer possible. In individual cases, the competent authority may permit temporary exceptions for plant components as far and as long as this is necessary for reasons of radiation protection.

The 17 nuclear power plants that are in the process of decommissioning are Greifswald (KGR, five units), Rheinsberg (KKR), Würgassen (KWW), Mülheim-Kärlich (KMK), Stade (KKS), Lingen

(KWL), Gundremmingen (KRB-A), Obrigheim (KWO), Isar 1 (KKI 1), Neckarwestheim I (GKN I) and Biblis (KWB Unit A und Unit B) as well as Philippsburg 1 (KKP 1).

D.5.3 Experimental and demonstration reactors

Four reactors for experimental and demonstration purposes are in the process of being decommissioned. The experimental and demonstration reactors at Niederaichbach (KKN) and Großwelzheim (HDR) as well as the Kahl experimental nuclear power plant (VAK) have been fully dismantled and released from regulatory control. The nuclear ship Otto Hahn has been released from regulatory control, the reactor pressures vessel (RPV) of the ship was removed and is stored at the Helmholtz-Zentrum Geesthacht.

D.5.4 Research reactors

Two research reactors with a thermal power of 1 MW and more have been permanently shut down, but do not have a decommissioning licence yet. Six research reactors with a thermal power of 1 MW and more are in various stages of decommissioning (including the FMRB Braunschweig, released from regulatory control except for one storage facility). One reactor (Jülich research reactor (FRJ-1)) has been fully dismantled and released from regulatory control.

26 research reactors no longer in operation with a thermal power of less than 1 MW, many of them zero power reactors for educational purposes, have already been fully removed. The reactor for educational purposes (AKR-1) was rededicated for a limited period of time according to § 57a of the Atomic Energy Act (AtG). In parallel, it was rebuilt as AKR-2 which commenced its operation in July 2005. The fuel core was removed from the Siemens training reactors in Aachen and Hanover and decommissioning applied for.

D.5.5 Nuclear fuel cycle facilities

The six commercial facilities of the nuclear fuel cycle are the Karlsruhe reprocessing plant (WAK) together with the Karlsruhe vitrification plant (VEK) in Karlsruhe (in the process of decommissioning) and five fuel fabrication plants at Hanau and Karlstein. Four of the five fuel fabrication plants released from regulatory control have already been fully removed. A facility in Karlstein has been converted for conventional use.

In addition, the facility Siemens Power Generation Karlstein (SPGK) – a research facility with hot cells – is in the process of decommissioning, which, however, is not considered as commercial facility of the nuclear fuel cycle in this report. For other non-commercial nuclear fuel cycle facilities, which were located in research centres, decommissioning has been completed.

An overview of commercial nuclear fuel cycle facilities in the process of decommissioning as well as those for which dismantling has been completed and which are released from regulatory control is given in Table L-18 of the annex.

D.5.6 Status of some current decommissioning projects

Greifswald nuclear power plant (KGR) and Rheinsberg nuclear power plant (KKR)

The dismantling of both the Greifswald nuclear power plant and the Rheinsberg nuclear power plant is managed by the publicly owned company Entsorgungswerk für Nuklearanlagen GmbH (EWN).

Eight nuclear power plant units of Soviet design, each with a power of 440 MWe (gross), had been planned for the nuclear power plant complex Lubmin near Greifswald (KGR). At the time of final shutdown in 1990, the first four units (VVER-440/W-230 type) had been in commercial operation since the 1970s (Unit 1 since 1973), whilst the fifth unit (VVER-440/W-213 type) had been in trial operation for a few months when it was shut down in 1989. Units 6 to 8 were still under construction. The decision to shut down all existing units and to halt commissioning of the remainder was mainly taken on the basis of financial considerations, because under federal atomic energy law, their continued operation would have required major structural conversions. The decommissioning licence was granted on 30 June 1995; until then, the operating licence from the former German Democratic Republic (GDR) remained valid. The dismantling of the KGR power plant units is well advanced. Parts of the plant buildings have already been put to industrial use or removed.

The Rheinsberg nuclear power plant (KKR) was the first nuclear power plant of the former GDR. It was equipped with a pressurised water reactor of the VVER type with a power of 70 MWe (gross), which had been in operation from 1966 to 1990. The first decommissioning permit was granted, as in the case of the KGR, in 1995. The radioactive waste, the reactor pressure vessel and a part of the clearable residues are disposed of via the facilities at the Lubmin site.

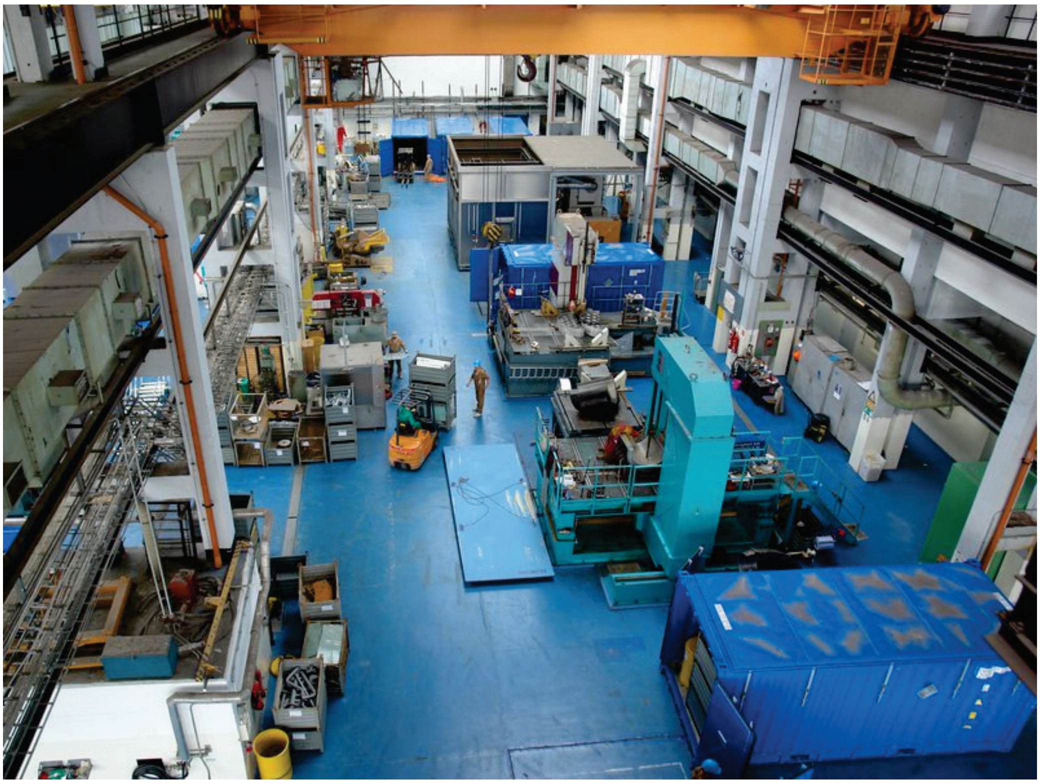
At present the focus of the work at the Lubmin site is on the preparation of the buildings of the KGR for clearance as well as on the treatment of the radioactive waste and residues from the operating period and from residual operation, which were initially emplaced in the Zwischenlager Nord (ZLN). The following facilities for storage and treatment are available:

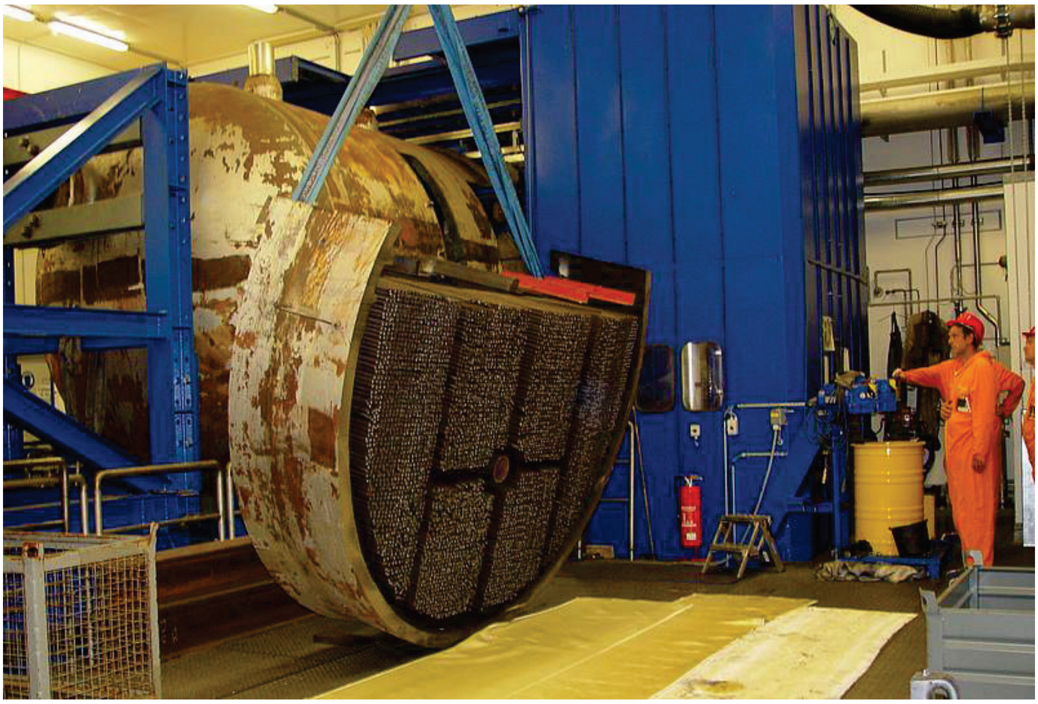
- the ZLN with several halls for the storage of radioactive waste as well as spent nuclear fuel and facilities for the treatment of radioactive waste and large components,
- the central active workshop (*Zentrale Aktive Werkstatt* – ZAW) with facilities for disassembly and decontamination (see Figure D-14), and
- the central decontamination and water treatment plant (*Zentrale Dekontaminations- und Wasseraufbereitungsanlage* – ZDW) in particular for decontamination, drying of waste containers and water treatment.

A facility for the disassembly of large components is in the planning stage which is intended for the disassembly of the steam generator, reactor pressure vessel and its internals, currently stored in the ZLN, over the next decades.

With the sixth modification licence of December 2007, the ZLN has a licence for the storage of solid radioactive residues/waste from other nuclear facilities with light water reactors (only from decommissioning and dismantling in the case of facilities for the commercial production of electricity) before and after treatment or conditioning at the Lubmin/Rubenow site up to five years each.

Figure D-14: View into the central active workshop (ZAW) with various disassembly and decontamination devices (upper picture) and the ZLN with the Caisson 4 (picture below) (Copyright: EWN)





Obrigheim nuclear power plant (KWO)

The Obrigheim nuclear power plant (KWO), a pressurised water reactor with a power of 357 MWe (gross), started operation in 1968. Since 1 January 2007, the KWO has been operated by EnBW Kernkraft GmbH (EnKK), like the two plants in Neckarwestheim and Philippsburg. The principal owner of the EnKK is the EnBW AG.

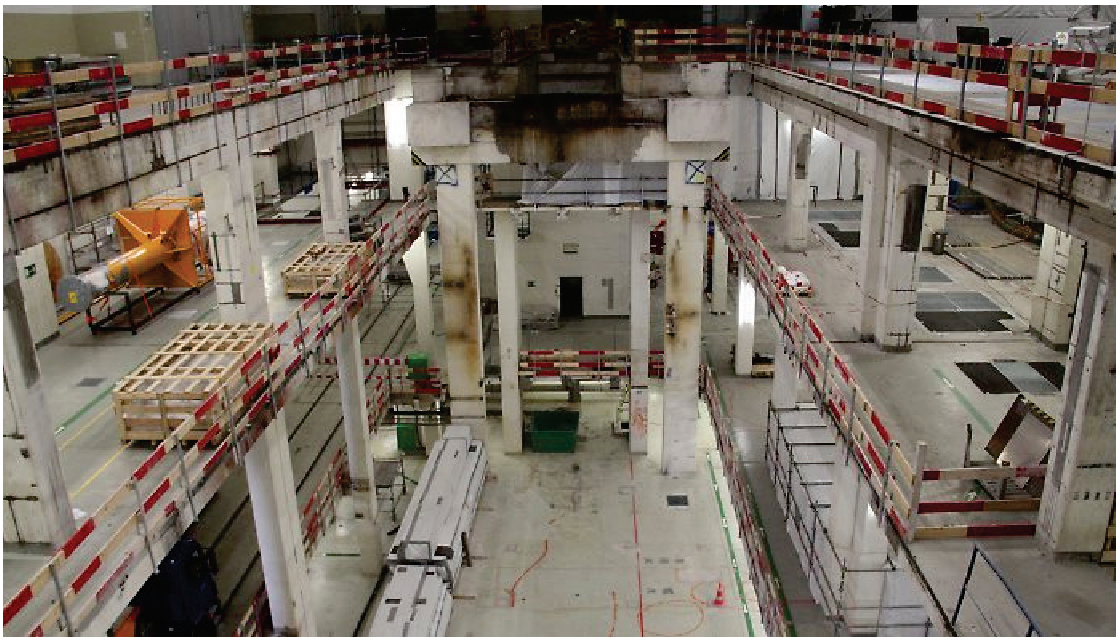
Power operation was discontinued on 11 May 2005. Immediate dismantling was chosen as decommissioning strategy for the KWO and for all other nuclear power plant units of EnBW already shut down or still to be shut down. Decommissioning and dismantling of the plant are to be carried out on the basis of four licences pursuant to § 7(3) AtG [1A-3]. The first decommissioning and dismantling licence for the final and permanent shutdown, which represented the overall dismantling project and specified the dismantling of parts of the plant in the supervised area, was granted on 28 August 2008. The second decommissioning and dismantling licence, which comprises the dismantling of plant components in the controlled area, was granted on 24 October 2011. After two steam generators that had been dismantled and stored on the premises of the KWO were already transported to the Entsorgungswerk für Nuklearanlagen GmbH (EWN) site in Lubmin in 2008, two further steam generators were transported after granting of the second decommissioning and dismantling licence with the same objective of decontamination and disassembly. The third decommissioning and dismantling licence, applied for in March 2010 and granted in April 2013, essentially comprises the dismantling and disassembly of the upper and lower core structure, the reactor pressure vessel and the so-called biological shield. The remaining systems and plant components will be dismantled under the fourth decommissioning and dismantling licence, which was applied for in November 2015 and whose granting is still pending. It comprises, e.g., parts of the ventilation systems, hoists, the crane system in the reactor building, and parts of a large material lock. Figure D-15 shows the empty KWO turbine building.

After transport of the reactor pressure vessel with a mass of approx. 135 Mg to the disassembly area of the reactor building in August 2015, disassembly of the reactor pressure vessel was started, mainly under water and remote-controlled. The work was finalised with the disassembly of the 1.5 m high and approximately 13 Mg heavy bottom head into 12 manageable individual segments, which were then packaged. At the end of July 2016, the disassembly of the reactor pressure vessel was completed.

The scheduled work for decommissioning is influenced by several site-specific factors, of which the storage of the 342 spent fuel assemblies in parallel with the dismantling work is of particular importance. The fuel assemblies were stored in the external fuel pool in the emergency building and will be transported to the Neckarwestheim storage facility. A corresponding modification licence for emplacement was already granted on 9 August 2016. The licence for the transport of the casks by ship via the river Neckar was granted on 16 May 2017. It is expected that by the end of the first quarter of 2018, all fuel assemblies will have been removed from Obrigheim.

The dismantling of the KWO within the nuclear regulatory framework is expected to be completed by the middle of the next decade. The remaining plant will then be a conventional industrial plant.

Figure D-15: View into the empty turbine building of the KWO (Copyright: EnBW)



Würgassen nuclear power plant (KWW)

The Würgassen nuclear power plant (KWW), a boiling water reactor with a power of 670 MWe (gross), was commissioned in 1971. The decision for decommissioning was taken at the end of May 1995 by the operator for economic reasons. A plant state free of nuclear fuel was reached in October 1996.

Immediate dismantling was chosen as the decommissioning option. Dismantling was separated into six phases, where conventional demolition of the buildings at the site is the last phase. The licence for the first dismantling phase under nuclear law was granted on 14 April 1997; the fourth and thus last licence for the fourth and fifth dismantling phases was granted on 6 September 2002. With the completion of dismantling of the reactor pressure vessel and concrete structures in the area of the containment, the relevant milestones regarding the full dismantling of the plant were reached as scheduled. In all parts of the controlled area buildings, decontamination of building surfaces and clearance measurements were performed.

The nuclear dismantling measures in the plant according to the fourth dismantling licence were completed in August 2014. The measurements for the clearance of the empty buildings and the plant site showed compliance with the clearance values. The release of the remaining buildings and the plant site from the scope of the AtG has begun, but will not yet be completed since the low and medium level radioactive waste will remain at the site in a rededicated building and a hall for keeping it ready for transport. The waste in these two storage facilities can only be removed after commissioning of the Konrad repository.

Stade nuclear power plant (KKS)

The Stade nuclear power plant (KKS) was equipped with a pressurised water reactor with a power of 672 MWe (gross). The plant started operation in 1972 and was permanently shut down on 14 November 2003. Immediate dismantling was chosen as decommissioning strategy. Dismantling of the plant was divided into five phases and applied for successively. The final dismantling phase comprises the conventional demolition of the buildings at the site.

The first licence under nuclear law was granted on 7 September 2005 and referred to the decommissioning of the entire complex as well as the residual operation of the plant, the construction of an operational storage facility for radioactive waste as well as the dismantling of first plant components and systems. The fourth dismantling phase relates to all residual dismantling measures in preparation for the conventional demolition. This licence was granted on 4 February 2011.

A plant state free of nuclear fuel was reached with the removal of the last fuel assemblies in April 2005. As part of the removal of large components, the four steam generators with a total mass of 660 Mg were shipped to Sweden in September 2007 for non-detrimental recycling. Dismantling of the reactor pressure vessel was completed in October 2010.

Currently, final dismantling measures are carried out in the KKS as well as decontamination and clearance of buildings. Radioactive waste from operation and decommissioning of the KKS are stored in the on-site storage building constructed for this purpose until delivery to the Konrad repository. During the dismantling activities, contamination from the power operation phase was detected at the bottom of the containment in January 2014. As a consequence, decontamination and clearance of the reactor building will require more time than originally planned. The completion of the licensed dismantling for release of the KKS from the scope of the AtG will be delayed by approx. 3.5 to 5 years, except for the storage facility. Subsequently, conventional demolition of KKS buildings and complete removal and return to greenfield conditions will take place within the framework of the fifth phase.

Gundremmingen nuclear power plant, Unit A (KRB-A)

The Gundremmingen nuclear power plant, Unit A (KRB-A) was the first commercial boiling water reactor in Germany. It had a power of 250 MWe (gross) and was in operation from 1966 to 1977. With the dismantling carried out since 1983, extensive know-how has been gained over decades in the disassembly, treatment and decontamination of radioactively contaminated materials and their clearance.

Since two other nuclear power plants (Units B and C) with boiling water reactor are in operation at the Gundremmingen site, some of the buildings and the infrastructure of the old facility Unit A were retrofitted for the operational requirements of the site as a technology centre. In this facility, the mechanical and chemical treatment and decontamination of components and residues from ongoing operation are carried out. Here, nuclear power plant components can be maintained, and special tools and equipment can be built and stored until the next use.

Mülheim-Kärlich nuclear power plant (KMK)

The Mülheim-Kärlich nuclear power plant (KMK), a pressurised water reactor with a power of 1,302 MWe (gross), was shut down for the last time after only 13 months of operation in September 1988. Following the decision on decommissioning and dismantling of the plant the corresponding application was submitted in June 2001. Three independent licensing steps are planned. The last fuel assemblies were removed in 2002.

The dismantling work started with the first licence for decommissioning and dismantling phase 1 on 16 July 2004. On 31 May 2013, the licence for dismantling phase 2a followed, which comprises, among other things, the dismantling of the reactor coolant system. Licence 2b of October 2015 now permits the dismantling of the reactor pressure vessel, the steam generators and the biological shield.

Parallel to the work in the supervised and controlled area, major parts of the premises have already been released from the scope of the AtG.

Karlsruhe reprocessing plant (WAK) and Karlsruhe vitrification plant (VEK)

The Karlsruhe reprocessing plant (WAK) on the premises of today's Karlsruhe Institute of Technology (KIT) was a test facility for the reprocessing of spent fuel from research, experimental and demonstration reactors as well as from power reactors. Apart from the objective of gaining operational experience, development projects for a German reprocessing plant were carried out on an industrial scale. Operation started in 1971 and ceased at the end of 1990 following a decision against a large-scale reprocessing plant. During this period, approximately 200 Mg of nuclear fuel originating from numerous reactors were reprocessed. The uranium and plutonium obtained in this process was delivered to nuclear fuel supply companies for further processing.

After final shutdown on 30 June 1991, the Federation, the *Land* of Baden-Wuerttemberg and the electric power companies decided to decommission and dismantle the reprocessing plant. Integral part of the dismantling strategy was the erection of the VEK in direct connection with the WAK for the safe enclosure of the liquid high active waste concentrate (HAWC) with an initial activity of $7.7 \cdot 10^{17}$ Bq in glass. The 140 canisters produced in the VEK were inserted into five transport and storage casks of the CASTOR® HAW 20/28 CG type and transported to the ZLN of the Entsorgungswerk für Nuklearanlagen GmbH (EWN) near Greifswald in February 2011. This reduced the activity inventory of the WAK by approx. 99 %.

The containers in which the HAWC was stored are currently disassembled. Due to the high dose rate in the cells and on the containers, disassembly is completely remote-controlled.

The current schedule for the complete dismantling of the entire plant, consisting of WAK and VEK, until demolition of the buildings extends to the end of the next decade.

Experimental nuclear reactor at Jülich (AVR)

The Jülich experimental reactor of the former Arbeitsgemeinschaft Versuchsreaktor GmbH (AVR GmbH) at the Jülich site (a separate site located on the premises of the Forschungszentrum Jülich GmbH (FZJ)), North Rhine-Westphalia, was a high temperature reactor designed as pebble bed reactor with a power of 15 MWe (gross) and was in operation from 1966 to 1988. An initial decommissioning application from the 1990s provided for the strategy of safe enclosure.

After the plant was taken over by Energiewerke Nord GmbH (EWN, now Entsorgungswerk für Nuklearanlagen GmbH) in May 2003, the objective of the project was changed to complete removal and return to greenfield conditions. This change in the objective also involved a change in the dismantling procedure. Due to the confined space conditions, on-site disassembly of the reactor vessel was rejected, and it was planned to remove the unloaded reactor vessel in one piece and to store it in a newly constructed storage facility on the premises of the FZJ for making use of the radioactive decay. In November 2008, the reactor vessel was backfilled with lightweight aerated concrete for better handling and fixation of the radioactive inventory (internals and graphite dust).

For lifting of the reactor vessel, an extension to the reactor building was constructed to serve as a material lock (see Figure D-16, left picture: inside view). This extension, which is much higher than the old reactor building, served to lift the reactor vessel out of its installation position and to lower it as well as to tilt it into a horizontal position for transport. Together with various locking systems of the existing building structures, the building of the material lock ensured the effective enclosure of the activity at all times. Lifting and setting down of the backfilled reactor vessel with a total mass of about 2,000 Mg took place in November 2014. In the following months, slings were welded to the lower part of the reactor vessel for tilting into the horizontal position so that it could be turned 90° in May 2015 and placed in its transport and storage rack. Together with it, the reactor vessel was transported to the storage facility on the premises of the FZJ (see Figure D-16, right), which is about 600 m away, in May 2015 using a heavy duty system. There, the reactor vessel is to be stored for about 30 to 60 years until later conditioning for disposal.

The AVR was integrated into the EWN Group through the merger of the nuclear areas of the FZJ and the Arbeitsgemeinschaft Versuchsreaktor GmbH, the Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH (JEN), in September 2015.

Figure D-16: Left: tilting the reactor vessel suspended on strand jacks in the material lock; right: transport of the reactor vessel to its storage facility by a heavy-duty system (Copyright: EWN)

Lingen nuclear power plant (KWL)

The Lingen nuclear power plant (KWL) was a boiling water reactor with a power of 252 MWe (gross) and had been commissioned in 1968. In 1977, the plant was permanently shut down due to technical considerations. After removal of the spent fuel, the Kernkraftwerk Lingen GmbH applied for dismantling of the turbine building and other conventional auxiliary systems no longer needed, and for safe enclosure of the residual part of the KWL remaining under nuclear regulatory supervision for about 25 years. The licence was granted on 21 November 1985.

With a notice of 14 November 1997, KWL was granted the licence for modification of the decommissioned plant and the operation under safe enclosure conditions for the purposes of disposing of the operational waste. Although disposal of the radioactive waste could not be continued after termination of emplacement in the Morsleben repository for radioactive waste (ERAM), the work for conditioning of the operational waste continued and has meanwhile been completed. The plant had been continuously optimised regarding improvement of occupational safety as well as fire prevention and radiation protection. An application for extending safe enclosure in 2004 was withdrawn after the legal validation of the planned commissioning of the Konrad repository; instead KWL applied for a licence for dismantling according to § 7(3) AtG in December 2008.

Dismantling is to be carried out in three partial projects. In the first licensing step initially applied for (partial project 1), all uncontaminated and contaminated plant components, including the steam converter, are to be dismantled. A second licensing step to be applied for later on (partial project 2) is to include the dismantling of the reactor pressure vessel and its internals, the biological shield, the residual dismantling, decontamination, and the plant's release from regulatory control. The third partial project comprises the conventional dismantling of buildings. The licence for the first phase of dismantling was granted in December 2015.

Initially, the infrastructure of the plant was prepared for dismantling. Disassembly of contaminated components has recently started. The dismantling strategy is mainly aimed at segmentation suitable for transport and the treatment and decontamination of material in external waste management facilities for reducing the waste volume. The low volume to be returned from waste conditioning can be prepared for delivery to the Konrad repository in the controlled area of the KWL or stored externally, i.a. in the Ahaus transport cask storage facility.

Hamm-Uentrop thorium high temperature reactor (THTR-300)

The Hamm-Uentrop thorium high temperature reactor (THTR-300) was equipped with a helium-cooled 308 MWe (gross) pebble bed high temperature reactor and started operation in 1983. Final shutdown of the plant was decided in September 1989, after the plant had been shut down for the scheduled annual revision on 29 September 1988. On 13 November 1989, the Federal Government, the *Land* of North Rhine-Westphalia, the operating company HKG and their proprietors signed a framework agreement concerning the completion of the THTR-300 project.

The first partial licence for decommissioning, unloading of the reactor core and the dismantling of plant components was granted on 22 October 1993. The fuel spheres were removed from the reactor core and transported to the Ahaus transport cask storage facility in CASTOR® THTR/AVR casks. The reactor core has been unloaded since 1995.

On 21 May 1997, the licence for operation under safe enclosure conditions (maintenance operation) was granted. Since October 1997, the plant has been in safe enclosure. Currently, it still consists of the reactor hall, the reactor operating building and the reactor auxiliary building with the respective plant components contained therein. All other structural parts and plant components, such as the turbine building, the electrical systems building, the emergency diesel generators, the transformer stations and the cell cooling towers were released from the scope of the AtG and partly dismantled. During maintenance operation, installations are operated for maintenance and monitoring of safe enclosure.

The duration of safe enclosure is specified to be about 30 years, but is not limited by a licensing condition. In 2017, details are to be submitted to the nuclear supervisory authority on whether (and if so, how long) maintenance operation is intended to be continued.

Radiochemistry Munich (RCM)

The decommissioning of laboratory buildings of the Radiochemistry Munich (RCM) in Garching is described representative of the various radiochemical laboratories in medicine, industry and research. These are not nuclear facilities within the meaning of the Joint Convention, but are addressed here due to the applicability of the approach to similar facilities in other contracting states.

The RCM is a central technical and scientific operating unit of the Technical University of Munich (TUM) and was founded on 1 January 2011. It emerged from the former Institut für Radiochemie of the TUM, whose building stock dates back to the 1960s. The fulfilment of current structural requirements necessitated a complete reconstruction of the main and the low-rise building. For this purpose, the main building was completely vacated and the resulting materials were cleared according to § 29 of the Radiation Protection Ordinance (StrlSchV) or classified as radioactive waste. The remaining building structures were decontaminated and cleared applying the clearance values according to Appendix III, Table 1, Column 8 StrlSchV, since the building is intended for conventional use as an office building after its gutting and conversion. Thus, the buildings were cleared for subsequent use. Figure D-17 shows the dismantling of the digestories in a laboratory of the RCM.

Figure D-17: Dismantling of the digestories in a radiochemical laboratory of the RCM (Copyright: Brenk Systemplanung GmbH)

The very heterogeneous use of the individual laboratory rooms and the use of a broad range of radionuclides led to the need to adjust the radiological characterisation and the clearance procedure individually to the radiological conditions of each room. In this case, the approach of determining nuclide vectors within the clearance procedure, which is possible in other nuclear facilities, could be applied only to a limited extent.

This dismantling was accompanied by a research project supported by the Federal Ministry of Education and Research (BMBF) to make experience gained available for the future dismantling of similar facilities, in particular for the effective procedure for radiological characterisation and clearance.

E Legislative and regulatory system

This section deals with the obligations under Article 18 to 20 of the Convention.

Developments since the Fifth Review Meeting:

Since the Fifth Review Meeting, there were several changes in nuclear law.

On 26 November 2015, the Fourteenth Act Amending the Atomic Energy Act [1A-28] entered into force. The Act transposed further provisions from Council Directive 2011/70/EURATOM [1F-36] on a Community framework for the responsible and safe management of spent fuel and radioactive waste into national law.

On 30 July 2016, the Act on the Reorganisation of the Organisational Structure in the Field of Disposal [1A-30] entered into force. The purpose of the Act is to clearly allocate the responsibilities for disposal and to ensure a more efficient handling of tasks. In particular, construction and operation of disposal facilities will in the future be transferred to a publicly owned company under private law, the Bundes-Gesellschaft für Endlagerung mbH (BGE). On the regulatory side, the regulatory functions of approval and supervision in the fields of disposal, storage and transports of radioactive waste are concentrated at the Federal Office for the Safety of Nuclear Waste Management (BfE).

On 16 June 2017, the Act on the Reorganisation of Responsibility in Nuclear Waste Management [1A-31] entered into force after state aid approval by the European Commission. The Act implements the recommendations of the Commission to Review the Financing for the Phase-out of Nuclear Energy (KFK) [KFK 16] and reorganises the responsibility for nuclear waste management. In the future, the Federation will be responsible for the implementation and financing of storage and disposal. The operators transfer the financial means into a public-law fund for the financing of nuclear waste management established with entry into force of the Act in the legal form of a foundation, which provides the Federation or a third party to be established by the Federation with the funds for the waste management steps to be carried out. In return, the spent fuel and radioactive waste, as well as the storage facilities defined in the Act, will be transferred to the Federation. In addition to the operator, the so-called controlling companies are also liable for the payment obligations remaining with the operator for the decommissioning of nuclear power plants and radioactive waste management.

On 27 April 2017, the *Bundestag* passed the Act on the Reorganisation of the Law on the Protection Against the Harmful Effects of Ionising Radiation [1A-29a]; on 12 May 2017, the *Bundesrat* approved the Act. The purpose of the Act is to transpose the provisions of Council Directive 2013/59/EURATOM [1F-24] "laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation" into national law. Among other things, this is to improve radiation emergency preparedness of the Federation and the *Länder*.

On 16 May 2017, the Act Amending the Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste and for the Amendment of Other Laws [1A-7b] largely entered into force. The Act serves to implement the recommendations of the Commission on the Storage of High-Level Radioactive Waste on the legal evaluation and the determination of the recommended decision-making bases. In addition, it includes, inter alia, two empowerments for issuing statutory ordinances on the introduction of safety requirements and requirements for the conduct of the preliminary safety analyses in terms of disposal.

E.1 Article 18: Implementing measures

> ***Article 18: Implementing measures***
>
> *Each Contracting Party shall take, within the framework of its national law, the legislative, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention.*

E.1.1 Implementation of the obligations under the Convention

Within the framework of its national law, the Federal Republic of Germany has already taken all the legislative, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention. The specific individual measures are described in the reporting on Article 19 of the Convention.

E.2 Article 19: Legislative and regulatory framework

> ***Article 19: Legislative and regulatory framework***
>
> *(1) Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of spent fuel and radioactive waste management.*
>
> *(2) This legislative and regulatory framework shall provide for:*
>
> *i) the establishment of applicable national safety requirements and regulations for radiation safety;*
>
> *ii) a system of licensing of spent fuel and radioactive waste management activities;*
>
> *iii) a system of prohibition of the operation of a spent fuel or radioactive waste management facility without a licence;*
>
> *iv) a system of appropriate institutional control, regulatory inspection and documentation and reporting;*
>
> *v) the enforcement of applicable regulations and of the terms of the licences;*
>
> *vi) a clear allocation of responsibilities of the bodies involved in the different steps of spent fuel and of radioactive waste management.*
>
> *(3) When considering whether to regulate radioactive materials as radioactive waste, Contracting Parties shall take due account of the objectives of this Convention.*

E.2.1 Legislative and regulatory framework

In Germany, the Basic Law (GG) [GG 49] sets forth the principles of a democratic social order, namely the government's responsibility to protect life and health and natural resources needed to sustain life, the separation of powers, the independence of licensing and supervisory authorities, and the supervision of administrative actions by independent courts. In the civil nuclear sector, legislation, administrative authorities and jurisdiction provide a framework for a system for the protection of life, health and property of workers and the general public against the dangers of nuclear energy and the harmful effects of ionising radiation, as well as for the regulation and supervision of safety during the construction, operation and decommissioning of nuclear facilities.

In accordance with the statutory requirements, in the field of nuclear technology, ensuring safety has priority over economic interests. By requiring that the necessary precautions have to be taken in the light of the state of the art of science and technology to prevent damage as a key guiding principle, internationally accepted safety standards, as specified in the “Fundamental Safety Principles” of the IAEA [IAEA 06], are taken into account. One principal objective of the German Federal Government’s safety policy in the field of nuclear energy was and still is that the operators of nuclear facilities maintain and further develop a high safety culture within their own sphere of responsibility.

Framework requirements due to the federal structure of the Federal Republic of Germany

The Federal Republic of Germany is a federal state. The responsibilities for law making and law enforcement are assigned differently to the organs of the Federation and the *Länder* according to the respective regulatory duties. Specifications are regulated by the provisions in the GG [GG 49] of the Federal Republic of Germany.

The legislative competence for the use of nuclear energy for peaceful purposes lies with the Federation, Article 73(1)(14) in conjunction with Article 71 GG. The further development of nuclear law is also a task of the Federation. The *Länder* are involved in the procedure.

The Atomic Energy Act (AtG) [1A-3] and the statutory ordinances based thereon are implemented, with a few exceptions, according to § 24(1) AtG in conjunction with Articles 87c, 85 GG by the *Länder* on behalf of the Federation. With respect to the legality and appropriateness of their action, the competent *Länder* authorities are subject to supervision by the Federation.

Article 85 GG

[Execution by the* Länder *on federal commission] (federal executive administration)

1. Where the *Länder* execute federal laws on federal commission, establishment of the authorities shall remain the concern of the *Länder*, except insofar as federal laws enacted with the consent of the *Bundesrat* otherwise provide.
2. The Federal Government, with the consent of the *Bundesrat*, may issue general administrative provisions. It may provide for the uniform training of civil servants and other salaried public employees. The heads of intermediate authorities shall be appointed with its approval.
3. The *Land* authorities shall be subject to instructions from the competent highest federal authorities. Such instructions shall be addressed to the highest *Land* authorities unless the Federal Government considers the matter urgent. Implementation of the instructions shall be ensured by the highest *Land* authorities.
4. Federal oversight shall extend to the legality and appropriateness of execution. For this purpose the Federal Government may require the submission of reports and documents and send commissioners to all authorities.

The competent supervisory and licensing authorities report to the Federation on law enforcement on demand. Within the frame of federal executive administration, the Federation has the right to require the submission of reports and documents and may issue binding directives to the *Land* authority in the individual case. The Federal Government may assume the competence for the subject matter, i.e. the decision on the merits, by exercising his right to issue directives. The responsibility for execution, i.e. the implementation of the decision towards the applicant or approval holder, rests with the competent *Land* authority.

Within the framework of nuclear procedures, other legal regulations also have to be considered, such as immission control legislation, water legislation, and building legislation. Legal regulations for assessing the environmental impact are, in general, part of the nuclear approval procedure.

In Germany, those concerned, e.g. applicants or approval holders or also third parties concerned, may take legal action against decisions of the public administration, so-called administrative acts, before the administrative courts (right to apply to the courts according to Article 19(4) GG [GG 49]). Action is brought against the competent *Land* authority, or the *Land* whose authority issued the administrative act, within the frame of federal executive administration. This also applies if the *Land* has taken a decision pursuant to a directive of the Federal Government. Also in case of failure of the authority to act, those concerned may take legal action. So, for example, the operators may claim granting of licences applied for or the residents the issuance of an administrative order for cessation of operation of a nuclear facility.

Involvement of international and European law

International treaties

In the hierarchy of legislation, the international treaties concluded by the Federal Republic of Germany in accordance with Article 59(2), first sentence of the GG [GG 49] are on the same level as formal federal law. As a matter of principle, rights and obligations under the treaty only apply to the Federal Republic of Germany as contracting party.

An overview of the most important international treaties of the Federal Republic of Germany in the fields of nuclear safety, radiation protection and liability as well as on national implementing provisions is given in Annex L-(d) [National laws and regulations].

For Germany, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [1E-1] entered into force on 18 June 2001.

In the field of nuclear liability, the Federal Republic of Germany is also a contracting party to

- the Paris Convention on Third Party Liability in the Field of Nuclear Energy of 1960 [1E-11],
- the Brussels Supplementary Convention of 1963 [1E-12], and
- the Joint Protocol of 21 September 1988 Relating to the Application of the Vienna Convention and the Paris Convention.

As one of currently 87 contracting parties, the Federal Republic of Germany joined the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter of 1972 [1E-3-1] and ratified it in November 1977. The convention revised and adopted in amended form (“London Protocol”) in 1996, which prohibits waste dumping at sea with a few exceptions, has also been ratified by the Federal Republic of Germany in October 1998. It entered into force on 24 March 2008.

A similar objective as of the London Convention is pursued by the OSPAR Convention of 1992, which entered into force in early 1998. It unites the Federal Republic of Germany and 14 other western and northern European countries and the European Union for the protection of the North-East Atlantic. The OSPAR Convention was established by the unification and expansion of the Oslo Convention of 1972 and the Paris Convention of 1974.

Legal provisions of the European Union

In Germany, legislation and administrative actions must take into account any binding requirement from regulations of the European Union (EU). However, the EU law – with some exceptions – is not directly applied in the national nuclear licensing and supervisory procedures, but must first be transposed into national law within certain time limits.

In its Title II, the Treaty establishing the European Atomic Energy Community (EURATOM Treaty) contains provisions for the encouragement of progress in the field of nuclear energy. Chapter 3 of this title regulates the protection of health and thus opens up a specific area of competence for the EURATOM.

In accordance with Articles 77 et seq. of the EURATOM Treaty, any utilisation of ores, source material and special fissile material is subject to the surveillance of EURATOM.

In the field of radiation protection, EURATOM basic standards were laid down for the protection of the health of the general public and workers against the dangers arising from ionising radiations [1F-18] based on Articles 30 et seq. (Health and Safety) of the EURATOM Treaty [1F-1]. Council Directive 96/29/EURATOM laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation [1F-18] of 1996 was transposed into national law by the Radiation Protection Ordinance (StrlSchV) [1A-8].

On 5 December 2013, the Council of the European Union adopted the new Council Directive 2013/59/EURATOM [1F-24] laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing 89/618/EURATOM [1F-29], 90/641/EURATOM [1F-20], 96/29/EURATOM [1F-18], 97/43/EURATOM [1F-23] and 2003/122/EURATOM [1F-22]. Thus, the existing five radiation protection directives of the European Union were combined and updated. The Directive takes account of new scientific findings and the recommendations of Publication 103 of the International Commission on Radiological Protection [ICRP 07]. It must be transposed into national law by 6 February 2018.

On 22 July 2009, Council Directive 2009/71/EURATOM establishing a Community framework for the nuclear safety of nuclear facilities [1F-5] entered into force to supplement the directives of the EURATOM on radiation protection. Thus, for the first time, binding European regulations on nuclear safety had been established. The Directive pursues the objective of maintaining and continuously improving nuclear safety. The EU member states are to take appropriate national measures to effectively protect workers and the general public against the dangers of ionising radiation from nuclear facilities. The Directive applies, among others, to nuclear power plants, research reactors, the storage of nuclear fuel (pursuant to § 6 of the Atomic Energy Act (AtG)) and the storage of radioactive waste if directly related to the respective nuclear facility and taking place on the same site, but not to repositories. The Directive includes provisions regarding the establishment of a legislative and regulatory framework for nuclear safety, the organisation and functions of the nuclear regulatory authorities, the obligations of the operators of nuclear facilities, the education and training of the staff of all parties involved, and the information of the public.

The Directive maintains the national responsibility for nuclear safety by, among others, the fact that the member states have the express right to take more stringent safety measures in addition to the provisions of the Directive in compliance with Community law (Article 2(2) of the Directive). On 8 December 2010, Council Directive 2009/71/EURATOM was transposed into national law with the Twelfth Act Amending the Atomic Energy Act.

In the field of nuclear waste management, the Council of the EU adopted Directive 2011/70/EURATOM [1F-36] establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste upon proposal from the European Commission. In this Directive, the member states are requested, in particular, to establish a national nuclear waste management programme and to report to the Commission. The member states shall specify, among other things, their nuclear waste management tasks as well as the technical and organisational boundary conditions of their programmes. Council Directive 2011/70/EURATOM was transposed into national law with the Fourteenth Act Amending the Atomic Energy Act of 20 November 2015.

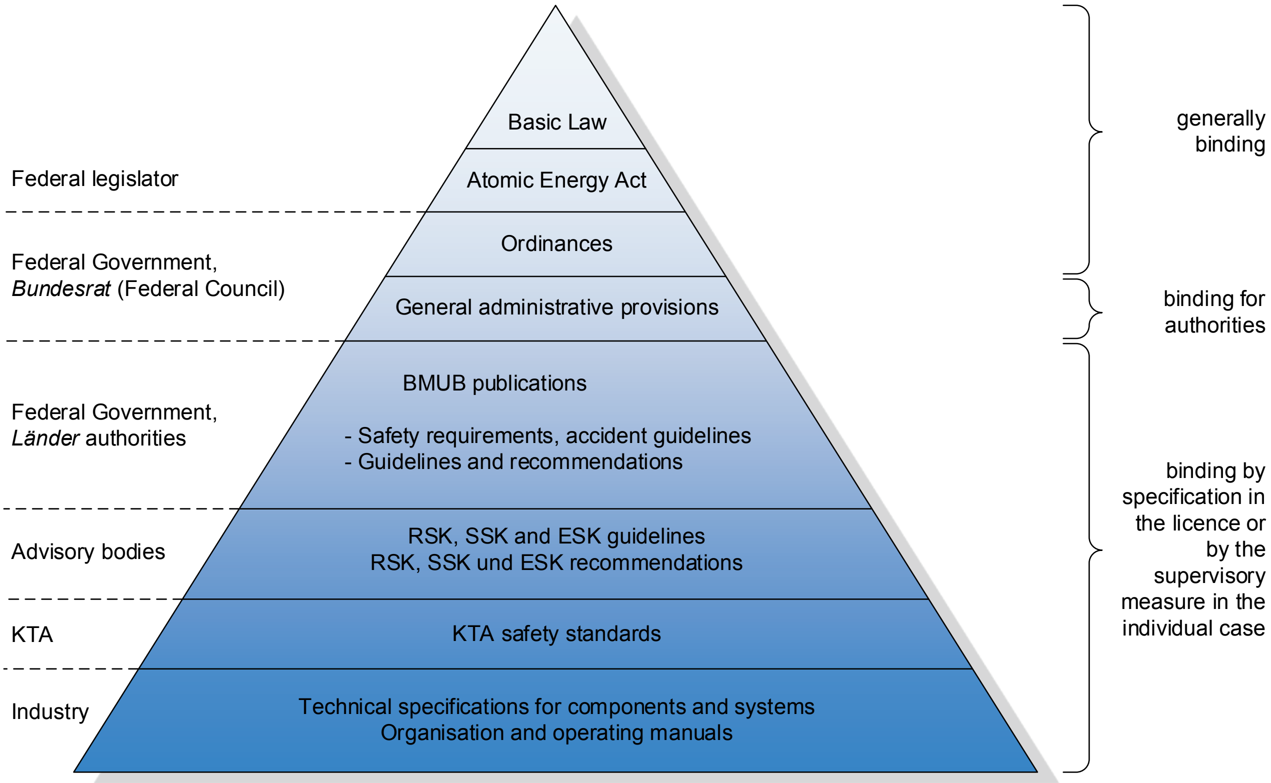
An overview of the legal provisions of the EU, in particular with regard to radiation protection and radioactive waste, is given in Annex L-(d), Part 1F [Agreements, general provisions].

E.2.2 National safety provisions and regulations

Hierarchical structure of the regulations

Figure E-1 shows the hierarchy of the national regulations, the authority or institution adopting the regulation and its degree of bindingness.

Figure E-1: Regulatory pyramid



Nuclear regulations not included in laws, ordinances and general administrative provisions have regulatory relevance by virtue of the legal requirement that necessary precautions have to be taken in the light of the state of the art in science and technology to prevent damage referred to in the various nuclear licensing conditions (e.g. in § 7(2)3 AtG [1A-3]: “A licence may only be granted if (…) the necessary precautions have been taken in the light of the state of the art of science and technology to prevent damage resulting from the erection and operation of the installation.”). According to legal practice, it can be assumed that the nuclear rules and regulations accurately reflect the state of the art. The dynamic improvement in safety requirements required by law is not bound by the formal development of standards. A substantiated scientific advancement being significant in terms of safety aspects will displace the application of an obsolete non-mandatory guidance instrument without explicitly needing to suspend it.

In this report, reference is made to the contents of the individual regulations when addressing the respective articles of the Convention. All of the listed regulations are accessible to the public and are published in official publications of the Federation.

The safety provisions were applied in all nuclear licensing and supervisory procedures and have been further developed, where necessary, particularly in the field of spent fuel and radioactive waste management, taking into account the state of the art in science and technology.

Acts

Basic Law

The GG [GG 49] contains fundamental principles which also apply to nuclear law. It also contains provisions on the legislative and administrative powers of the Federation and the *Länder* regarding the use of nuclear energy. As defined in Article 73 GG, the Federation shall have exclusive legislative power with respect to "the production and utilisation of nuclear energy for peaceful purposes, the construction and operation of facilities serving such purposes, protection against hazards arising from the release of nuclear energy or from ionising radiation, and the disposal of radioactive substances". The *Länder* carry out their tasks under nuclear law on behalf of the Federation (federal executive administration). Federal supervision extends to the legality and appropriateness of execution by the *Land* authorities. According to Article 85(3) GG, these shall be subject to the instructions from the competent highest federal authority (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)).

The basic rights laid down in the Basic Law, in particular the basic right to life and physical integrity, form the basis for the standard to be applied to the protective and preventive measures at nuclear facilities, which is further specified in the above hierarchy levels of the pyramid.

Atomic Energy Act

The AtG [1A-3] was promulgated on 23 December 1959 after the Federal Republic of German had officially renounced any use of atomic weapons and, since then, has been amended several times. The purpose of the AtG according to the amendment of 2002 is to phase out the use of nuclear energy for commercial electricity production in a controlled manner. Until then, undisturbed operation of the nuclear facilities is to be ensured, life, health and property are to be protected against the hazards of nuclear energy and the detrimental effects of ionising radiation and, furthermore, compensation for any damage and injuries incurred is to be provided. It also serves the purpose of preventing the internal or external security of the Federal Republic of Germany from being endangered by the application of nuclear energy. Another purpose of the Atomic Energy Act is to ensure that the Federal Republic of Germany meets its international obligations in the field of nuclear energy and radiation protection. The AtG includes the general national provisions for protective and precautionary measures, radiation protection and radioactive waste and spent fuel management in Germany and constitutes the basis for the associated ordinances.

Besides its purpose and general provisions, the AtG also includes supervisory provisions, liability regulations, general regulations on administrative responsibilities, and regulations on administrative fines.

In order to protect against the hazards emanating from radioactive substances and to control their use, the AtG requires that the construction and operation of nuclear facilities shall be subject to regulatory licensing. The AtG regulates, in particular, prerequisites and procedure for the granting of licences, the performance of supervision as well as the consultation of authorised experts (§ 20 AtG) and the charging of costs (§ 21 AtG). In the field of waste management, the AtG stipulates that the Federation shall construct facilities for the safekeeping and disposal of radioactive waste (§ 9a(3) AtG, first sentence). The construction and operation of such facilities requires plan approval (§ 9b(1) AtG). In the cases where the site of a facility is determined by federal law, a licence shall substitute the plan approval (§ 9b(1a) AtG). Due to the Repository Site Selection Act (StandAG) [1A-7a], § 9b(1a) AtG has been inserted into the Atomic Energy Act as a new paragraph. The costs incurred for the planning, construction and operation of facilities for the safekeeping and disposal of radioactive waste are principally borne by the waste producers through fees and contributions together with advance payments according to §§ 21a and 21b AtG in conjunction with the Repository Prepayment Ordinance (EndlagerVlV) [1A-13]. However, insofar as the financing obligation for facilities for the disposal of radioactive waste pursuant to § 1 of the Waste Management Transfer Act has passed to the fund pursuant to § 1(1) of the Waste Management Fund Act, the fund will be liable to advance payments instead of the licence holder. This applies to the site selection procedure, which is financed through cost allocations to the waste producers according to §§ 21 et seq. of the Act Amending the StandAG [1A-7b], accordingly. With the transfer of the spent fuel and radioactive waste to the third party commissioned with storage management by the Federation, the responsibility for waste management according to § 9a(1) AtG is also transferred as stipulated in the Waste Management Transfer Act.

However, most of the regulations laid down in the AtG are not to be regarded as exhaustive but are further concretised, both in the area of procedures and the substantive requirements, by ordinances promulgated on the basis of the AtG as well as by the non-mandatory guidance instruments.

The AtG concretely requires that certain activities are subject to licensing. So, for example, § 7 AtG stipulates that the construction, operation or the ownership of a facility for the production, processing, treatment or fission of nuclear fuel, a material alteration of such facility or its operation and also decommissioning require a licence. There are similar stipulations in § 6 AtG for the storage of nuclear fuel, in § 9 AtG for the treatment, handling and other use of nuclear fuel outside of the facilities specified in § 7 AtG, and in § 9b AtG for facilities of the Federation for the safekeeping and disposal of radioactive waste.

With the Tenth Act Amending the Atomic Energy Act of 24 March 2009 [1A-24], operation and closure of the Asse II mine were subjected to the provisions of the AtG on federal facilities for the disposal of radioactive waste by insertion of § 57b, and it substantiated the responsibility of the Federal Office for Radiation Protection (BfS) as its operator.

The Eleventh Act Amending the Atomic Energy Act of 8 December 2010 extended the lifetimes of the German nuclear power plants within the framework of the energy concept adopted by the Federal Government, i.e. by eight years for plants built before 1980 and by 14 years for the other plants.

The Twelfth Act Amending the Atomic Energy Act of 8 December 2010 transposed the obligations under Council Directive 2009/71/EURATOM [1F-5] of the European Union establishing a Community framework for the nuclear safety of nuclear facilities – unless they already represented applicable national law – into national law.

In the light of the events in Fukushima, the Thirteenth Act Amending the Atomic Energy Act of 31 July 2011 [1A-25] implemented the decision of the Federal Government to phase out the use of nuclear energy for commercial electricity production in the Federal Republic of Germany. The amendments to the AtG determine the phase out of electricity production by nuclear facilities by 2022 on a step-by-step basis. The authorisation for power operation has expired and will expire as follows:

- for the nuclear power plants Biblis Unit A, Neckarwestheim I, Biblis Unit B, Brunsbüttel, Isar 1, Unterweser, Philippsburg 1 and Krümmel the date of entry into force of the Act (the reactors thus remain permanently shut down,

- 31 December 2015 for the Grafenrheinfeld nuclear power plant,

- 31 December 2017 for the Gundremmingen B nuclear power plant,

- 31 December 2019 for the Philippsburg 2 nuclear power plant,
- 31 December 2021 for the nuclear power plants Grohnde, Gundremmingen C and Brokdorf,
- 31 December 2022 for the nuclear power plants Isar 2, Emsland and Neckarwestheim II.

Further provisions of Council Directive 2011/70/EURATOM [1F-36] on a Community framework for the responsible and safe management of spent fuel and radioactive waste were transposed into national law with the Fourteenth Act Amending the Atomic Energy Act of 20 November 2015 [1A-28]. The Act mainly contains the duties directed to the operators of waste management facilities – including disposal facilities – such as a corresponding extension of the operators' obligation already enshrined in law to carry out periodic reviews and assessments of the safety of a facility or installation. Furthermore, it contains the standardisation of the State's obligation to draw up a National Programme (NaPro) for spent fuel and radioactive waste management [BMUB 15] for Germany.

Act on the Reorganisation of the Law on the Protection Against the Harmful Effects of Ionising Radiation

On 27 April 2017, the *Bundestag* passed the Act on the Reorganisation of the Law on the Protection Against the Harmful Effects of Ionising Radiation [1A-29a]; on 12 May 2017, the *Bundesrat* approved the Act. This Act was drawn up against the background of Council Directive 2013/59/EURATOM [1F-24] laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation of 5 December 2013, which entered into force on 6 February 2014 and is to be transposed into national law in the member states by 6 February 2018.

Within the framework of this Act, which amends various acts, a new act regulating the protection against the harmful effects of ionising radiation (Radiation Protection Act – StrlSchG) is to be enacted, which will reorganise the German radiation protection system according to the distinction between existing, planned and emergency exposure situations as defined by Council Directive 2013/59/EURATOM. At the same time, the amendment will, among other things, result in the adaptation of numerous specifications according to the state of the art in science and technology, thus improving, for example, radiation emergency preparedness of the Federation and the *Länder.*

In addition, with this Act, the Act on the Precautionary Protection of the Population against Radiation Exposure (Precautionary Radiation Protection Act – StrVG) was repealed and other acts and ordinances amended.

Lex Asse

The Act on Speeding up the Retrieval of Radioactive Waste and the Closure of the Asse II Mine ("Lex Asse") of 20 April 2013 [1A-26] contained the amendment of § 57b AtG. The amendment of § 57b AtG creates the legal framework for an accelerated procedure. Compared to the current legal situation, the following changes have been made:

- definition of the objective of retrieval of the waste prior to a closure of the mine,
- specifications on criteria for discontinuation,
- opening the way for procedural flexibility,
- reduction of uncertainties about the enforcement and development of provisions to facilitate law enforcement.

Repository Site Selection Act

On 27 July 2013, the Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste and for the Amendment of Other Laws (Repository Site Selection Act – StandAG) [1A-7a] entered into force. As defined in the StandAG, a comparative site selection procedure for the whole of Germany is planned for the search for a suitable repository site which covers the potential host rock types occurring in Germany, i.e. salt, clay and crystalline rock.

The actual procedure for site selection was preceded by the work of the Commission on Storage of High-Level Radioactive Waste from May 2014 to June 2016. Its task was to examine and assess the relevant fundamental issues for the selection procedure with regard to radioactive waste management as well as to develop proposals for the decision criteria, the performance of the procedure and for public participation. Furthermore, the Commission has also evaluated the StandAG and made proposals for its amendment. The results of the work of the Commission were submitted to the *Bundestag* in the form of a report [KOM 16] in July 2016.

The recommendations of the Commission were implemented i.a. in the Act Amending the StandAG [1A-7b], which largely entered into force on 16 May 2017. It includes two empowerments for issuing statutory ordinances on the introduction of safety requirements and requirements for the conduct of the preliminary safety analyses in terms of disposal. Several amendments have been made to the version of the Repository Site Selection Act of 27 July 2013. In particular, more detailed regulations were introduced for comprehensive and transparent participation procedures in order to fully involve the public in the selection procedure before taking decisions. Based on the Commission's recommendations on the performance of the site selection procedure, the phases of the procedure were specified and adapted, in particular to take account of the existing need for comprehensive and early participation and to ensure effective performance of the respective phases. In addition, criteria were developed for site selection, taking into account the recommendations of the Commission, and a regulation was established for early safeguarding of areas potentially suitable for disposal against changes which could impair its suitability for disposal. In addition, with the amendment to the Act it was decided to use in future the internationally used term "high level radioactive waste" in connection with the site selection the disposal of which is intended to be the primary purpose of the repository.

The objective of the Act Amending the StandAG [1A-7b] is to determine in a participatory, science-based, transparent, self-questioning and learning procedure the site for the disposal of heat-generating radioactive waste which ensures the best possible safety for a period of one million years. The selection procedure is based on statutory minimum requirements, exclusion criteria and weighing criteria, which are to be applied in several phases of the procedure for narrowing the site options and which are to be underpinned by safety investigations to be refined successively and further test criteria.

The project implementer for the transparent, science-based search and selection process is the publicly owned Bundes-Gesellschaft für Endlagerung mbH (BGE), founded in July 2016. The Federal Office for the Safety of Nuclear Waste Management (BfE), established within the portfolio of the BMUB, is responsible for monitoring the implementation of the site selection procedure.

The public is to be given the opportunity of intensive participation in the process of site selection at the national and regional level. The BfE is also the organiser and coordinator of public participation.

At the national level, the National Advisory Board (*Nationales Begleitgremium*) to accompany the selection process was formed in December 2016. In a transitional phase, this board is composed of nine members, six of which are renowned public figures appointed by the *Bundestag* and the *Bundesrat*. The other three members are citizens who were selected from a random sample according to a qualified selection system and appointed by the Federal Environment Minister.

Among these three members is a representative of the young generation. It is intended, to double the number of members of the board to 18 persons.

The central task of the National Advisory Committee is to accompany the process of site selection as a mediating and independent body until reaching a decision on a site, in particular with regard to public participation. For this purpose, advice may be sought from a scientific advisory board, which can be convened by it, or from external experts or scientific opinions.

The public in the site regions proposed in the site selection procedure will be involved in the procedure by regional conferences and the subareas expert conference. In addition, there will be a Council of the Regions at the cross-regional level. The social bodies will be provided with the necessary resources.

Act on the Establishment of a Federal Office for the Safety of Nuclear Waste Management

With the StandAG [1A-7a], the Act on the Establishment of a Federal Office for Nuclear Waste Management (now BfE) (BfkEG) [1A-27] was also passed in 2013. It entered into force on 1 January 2014. Pursuant to § 2 of the Act, the BfE carries out administrative tasks by the Federation in the field of licensing of facilities of the Federation for the safekeeping and disposal of radioactive waste assigned to it by the Atomic Energy Act, the Repository Site Selection Act or other federal laws or by virtue of these laws. Among other things, the BfE is to develop and define site-specific exploration programmes and test criteria. Furthermore, the BfE examines the proposals of the project implementer and monitors the implementation of the site selection procedure. It is the organiser and coordinator of public participation in the site selection procedure. The BfE started its work on 1 September 2014. It is headquartered in Berlin. Further offices are located in Salzgitter and Bonn.

Act on the Reorganisation of the Organisational Structure in the Field of Disposal

On 30 July 2016, the Act on the Reorganisation of the Organisational Structure in the Field of Disposal (EndLaNOG*)* [1A-30] entered into force. The purpose of the Act is to clearly allocate responsibilities in the fields of radiation protection and disposal, and to ensure a more efficient handling of tasks. In the field of disposal, on 25 April 2017, the operator and operational management tasks, which had previously been carried out by the BfS on the one hand and the administrative aides by the Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH (DBE) and Asse-GmbH on the other hand, were transferred to a newly founded, publicly owned company under private law, the BGE and bundled there. DBE, Asse-GmbH and parts of the BfS will be merged into the new company. The BGE is headquartered in Peine.

The licensing and supervisory tasks are concentrated at the BfE. The responsibilities are clearly defined due to the separation of operator tasks and licensing and supervisory tasks.

The BfS will continue its work as an independent higher federal authority and will concentrate exclusively on the various issues relating to radiation protection.

Act on the Reorganisation of Responsibility in Nuclear Waste Management

On 16 June 2017, the Act on the Reorganisation of Responsibility in Nuclear Waste Management [1A-31] entered into force after state aid approval by the European Commission. The Act implements the recommendations of the Commission to Review the Financing for the Phase-out of Nuclear Energy (KFK) [KFK 16] and reorganises the responsibility for nuclear waste management. It secures the financing of decommissioning, dismantling and waste management in the long term without passing on the costs incurred for this purpose unilaterally to society and without jeopardising the economic situation of the operators.

The operators of the nuclear power plants will continue to be responsible for the entire management and financing of decommissioning, dismantling and proper packaging of the radioactive waste. In the future, however, the Federation will be responsible for storage and disposal and its financing. This task will be performed by the publicly owned companies. The funds for storage and disposal of up to around 24 billion euros were provided to the Federation by the operators and transferred to a fund, organised as a foundation under public law, in the beginning of July 2017. The fund collects, deposits and disburses the funds.

The following acts were enacted under the Act on the Reorganisation of Responsibility in Nuclear Waste Management:

- **Article 1: Act on the Establishment of a Fund for the Financing of Nuclear Waste Management (Waste Management Fund Act)**

  The Act regulates the establishment of a foundation under public law ("fund") for the financing of nuclear waste management and the terms of payment into the fund. The operators of the nuclear power plants had to transfer the basic amount of around 17 billion euros to the fund by 1 July 2017. In addition, they can ultimately transfer the liability for interest rate and cost risks to the State against the payment of a risk premium of an extra 6 billion euros, also in the form of an instalment agreement to be concluded in accordance with § 7(4) of the Waste Management Fund Act.

- **Article 2: Act Regulating the Transfer of Financing and Action Obligations for the Management of Radioactive Waste from Operators of Nuclear Power Plants (Waste Management Transfer Act)**

  In conjunction with the Waste Management Fund Act, this Act regulates the transfer of the financing and action obligations of the nuclear power plant operators for the management of radioactive waste from operation and decommissioning, safe enclosure as well as dismantling of nuclear fission facilities for the commercial production of electricity. Accordingly, on the one hand, the Federation assumes the financing obligation for storage and disposal of radioactive waste upon payment of the basic amount by the operators pursuant to § 7(2) of the Waste Management Fund Act or the first instalment according to an agreement on payment in instalments effective under the Waste Management Fund Act. On the other hand, the action obligation on the part of the operators with regard to the management of their radioactive waste is transferred to the Federation from the time of transfer of the properly packaged waste to the publicly owned storage facility operator (BGZ Gesellschaft für Zwischenlagerung mbH). In addition, the storage facilities listed in the annex to the Act are transferred to the Federation at specified times.

- **Article 3: Amendment of the Atomic Energy Act**

  With the amendment of § 7(3) AtG, the Act aims, among other things, at immediate decommissioning and dismantling of nuclear power plants whose authorisation for power operation expired or whose power operation has ceased permanently. Safe enclosure is thus no longer a decommissioning option. In individual cases, the competent authority may permit temporary exceptions for plant components as far and as long as this is necessary for reasons of radiation protection.

- **Article 7: Act on Transparency Regarding the Costs of Decommissioning and Dismantling Nuclear Power Plants and the Packaging of Radioactive Waste (Transparency Act)**

  The Transparency Act regulates, inter alia, certain obligations to provide information to the Federal Office for Economic Affairs and Export Control (BAFA), but also requirements concerning the provisions of nuclear power plant operators for the waste management obligations remaining with the operator. In this way, financing shall be secured by means of more transparency and better auditability also for tasks that remain within the responsibility for financing and action of the operators, in particular in terms of the decommissioning and dismantling of nuclear power plants. In addition, the objective of the Act is to provide clarity to the Federation on the cost estimates on which the formation of provisions for decommissioning are based.

- **Article 8: Act on the Follow-up Liability for Dismantling and Waste Management Costs in the Nuclear Energy Sector (Follow-up Liability Act)**

  This Act replaces the Federal Government's draft of an Act on the follow-up liability for dismantling and waste management costs in the nuclear energy sector of 9 November 2015.

  The Follow-up Liability Act also attributes the payment obligations with respect to the costs for decommissioning and dismantling of the facilities, the payment obligations to the fund according to the Waste Management Fund Act as well as the payment obligations for cost increases in radioactive waste management that remain with the companies in the event of non-payment of the risk premium to the so-called controlling companies in addition to the controlled operating company. This is to prevent that the electric power utilities can free themselves wholly or partly from the liability for the costs of nuclear phase-out and the management of their radioactive waste by restructuring.

In addition, the Act on the Reorganisation of Responsibility in Nuclear Waste Management also amended other acts and ordinances (the Atomic Energy Act by Article 3, the Repository Site Selection Act by Article 4, the Repository Prepayment Ordinance by Article 5 and the Radiation Protection Ordinance by Article 6).

Statutory ordinances

For further concretisation of the legal regulations, the AtG includes authorisations for the promulgation of statutory ordinances (see the list in § 54(1) AtG [1A-3]). These statutory ordinances require the consent of the *Bundesrat*. The *Bundesrat* is a constitutional organ of the Federation in which the governments of the *Länder* are represented.

In this regard, a number of statutory ordinances have been issued which are also relevant for spent fuel and radioactive waste management. The most important ordinances relate to:

- radiation protection (Radiation Protection Ordinance – StrlSchV [1A-8]),
- the licensing procedure (Nuclear Licensing Procedure Ordinance – AtVfV [1A-10]),
- the transboundary movement of radioactive waste or spent fuel (Nuclear Waste Shipment Ordinance – AtAV [1A-18]),
- advance payments for the construction of radioactive waste disposal facilities (Repository Prepayment Ordinance – EndlagerVlV [1A-13]),
- provisions for sufficient coverage (Nuclear Financial Security Ordinance – AtDeckV [1A-11]), and
- the reporting of reportable events (Nuclear Safety Officer and Reporting Ordinance – AtSMV [1A-17]).

The safety provisions and regulations of the Atomic Energy Act and associated ordinances are further concretised by general administrative provisions (AVV), announcements by the BMUB, guidelines and recommendations of the Reactor Safety Commission (RSK), the Commission on

Radiological Protection (SSK) and the Nuclear Waste Management Commission (ESK), safety standards of the Nuclear Safety Standards Commission (KTA) and conventional technical standards.

General administrative provisions

Statutory ordinances may contain additional authorisations for the promulgation of the AVV. Such provisions regulate the actions of the authorities but they only have a direct binding effect for the administration. They have a direct external effect if they are used as a basis for administrative decisions.

In the nuclear field, there are six AVV which deal with the following topics:

- calculation of radiation exposure during specified normal operation of nuclear facilities [2-1],
- radiation passports [2-2],
- environmental impact assessments [2-3],
- environmental monitoring [2-4],
- monitoring of food [2-5],
- monitoring of feed [2-6], and
- rapid alert system [2-7].

Announcements by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)

After having consulted the *Länder*, the BMUB publishes regulatory guidelines (in the form of requirements, guidelines, criteria and recommendations). In general, these are regulations adopted in consensus with the competent licensing and supervisory authorities of the *Länder* on the uniform application of the AtG (see reporting on Article 20 of the Convention). The announcements of the BMUB describe the view of the federal supervisor on general issues relating to nuclear safety and the administrative practice, and they provide orientation for the *Land* authorities regarding the enforcement of the Atomic Energy Act. Unlike the general administrative provisions, the announcements are not binding for the authorities of the *Länder*. Their relevance is also given by the right of the BMUB to issue binding individual directives for particular cases to the *Land* authorities. Currently, about 100 BMUB regulatory guidelines exist in the nuclear field. The part that is also applicable to the management of spent fuel and radioactive waste is included in Annex L-(d).

Related to spent nuclear fuel and radioactive waste management are, in particular

- the Safety Criteria for the Final Disposal of Radioactive Wastes in a Mine [3-13],
- the Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste [BMU 10],
- the Guideline concerning Emission and Immission Monitoring of Nuclear Installations (REI) [3-23],
- the Guideline on the Control of Radioactive Residues and Radioactive Waste [3-60],

- the Guide to the Decommissioning, the Safe Enclosure and the Dismantling of Facilities or Parts thereof as Defined in § 7 AtG [3-73],
- the Guideline for Physical Radiation Protection Control for the Determination of Body Doses, Part 1: Determination of the Body Dose from External Radiation Exposure (§§ 40, 41, 42 StrlSchV; § 35 RöV) [3-42-1],
- the Guideline for Physical Radiation Protection Control for the Determination of Body Doses, Part 2: Determination of the Body Dose from Internal Radiation Exposure (Incorporation Monitoring) (§§ 40, 41 and 42 StrlSchV) of 12 January 2007 [3-42-2],
- the Guideline concerning the Radiation Protection of the Personnel during Maintenance, Modification, Waste Management and Dismantling Work in Nuclear Facilities and Installations, Part 2: The Radiation Protection Measures during the Operation and the Decommissioning of a Facility or Installation (IWRS II) [3-43-2].

The Safety Criteria for the Final Disposal of Radioactive Wastes in a Mine [3-13], published in the Federal Law Gazette (*Bundesanzeiger*) at the beginning of 1983, had the task to concretise the requirement to take the necessary precautions to prevent damage pursuant to the AtG, which is also to be met for disposal. In the time following, international recommendations and standards on radiation protection and disposal of radioactive waste have been substantially revised and updated according to new findings. Against this background, the former Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has developed the safety requirements for the disposal of heat-generating radioactive waste. The safety requirements put the necessary precautions to be taken in the light of the state of the art of science and technology to prevent damage in concrete terms that are to be complied with regarding the construction, operation and closure of a repository for heat-generating radioactive waste and to be reviewed within the plan approval procedure by the respective licensing authority.

The *Länder* Committee for Nuclear Energy agreed on the version of 30 September 2010 of the “Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste” [BMU 10] from a technical point of view. With the amended Repository Site Selection Act, it was introduced that the BMUB will in the future define the safety requirements for disposal in a statutory ordinance. A corresponding ordinance is currently being drafted.

Guidelines and recommendations of the SSK and the ESK

The recommendations of the SSK and the ESK play an important role with respect to licensing and supervisory procedures in the field of spent fuel and radioactive waste management. These independent expert commissions advise the BMUB on issues relating to radiation protection and nuclear waste management. By appointing experts in different technical fields, it is intended that the full bandwidth of scientific knowledge should be reflected in these two bodies (see reporting on Article 20 of the Convention).

The SSK and ESK submit their results of consultations to the BMUB in the form of statements or recommendations which are prepared in committees and working groups. Via publication in the Federal Law Gazette, these recommendations become part of the nuclear rules and, in particular cases, their application is recommended by circulars of the BMUB. The system of the BMUB being advised by independent experts from various disciplines has proved effective.

On the basis of the findings gained in connection with the accident at the Fukushima nuclear power plant, the SSK has subjected the technical bases for emergency protection in Germany and the related regulations to a review. The determination of the accident spectrum which is the basis for emergency planning was based more on the potential impact than on the calculated probability of occurrence of accidents. In a first step, the recommendation "Planning areas for emergency response near nuclear power plants" [4-24] was adopted in February 2014 and, in addition to this, the recommendation "Planning areas for emergency response near decommissioned nuclear power plants" [4-25] was adopted on 20/21 October 2014.

At its meeting on 19/20 February 2015, the SSK adopted new "Basic Recommendations for Disaster Control in the Vicinity of Nuclear Power Plants" [4-26]. With this further development of the existing recommendations for the preparation of disaster control plans of 2008, the results of the review of the regulations for emergency preparedness carried out after the accident at the Fukushima nuclear power plant were taken into account.

At its meeting on 11/12 December 2014, the SSK adopted a recommendation on the introduction of dose constraints for the protection against occupational radiation exposure in transposing Council Directive 2013/59/EURATOM into German radiation protection law [4-27]. Previously, the SSK had examined by way of an exemplary view of typical areas of occupational radiation protection the extent to which already existing regulations on dose constraints and optimisation tools are compatible with the requirements of Council Directive 2013/59/EURATOM, and whether an improvement in occupational radiation protection is to be expected by the introduction of dose constraints in terms of this Directive. For none of the areas examined, the SSK considered it necessary to introduce dose constraints at the level of relevant laws and ordinances for the implementation of Council Directive 2013/59/EURATOM.

At its meeting on 15/16 September 2016, the SSK adopted recommendations on the radiological protection during the closure of the Asse II mine [4-28]. Accordingly, the SSK recommends, among other things, ensuring that the three principles of radiological protection – justification, optimisation and application of dose limits – are given due consideration during the closure of the Asse II mine.

As regards the storage of spent fuel and radioactive waste, the following recommendations prepared by the ESK are of particular importance:

- Guidelines for dry cask storage of spent fuel and heat-generating waste [4-2], and
- Guidelines for the storage of radioactive waste with negligible heat generation [4-3] and their implementation [4-16].

The following recommendation prepared by the ESK is relevant for the decommissioning of nuclear facilities:

- Guidelines for the decommissioning of nuclear facilities [4-4].

In November 2010, the ESK adopted recommendations for guides to the performance of periodic safety reviews for storage facilities for spent fuel and heat-generating radioactive waste [4-5]. Based on them, the ESK guidelines for the performance of periodic safety reviews and on technical ageing management for storage facilities for spent fuel and heat-generating radioactive waste [4-5a] were published in March 2014, which concretise review and assessment of the safety status of the storage facilities to be carried out every ten years in accordance with § 19a(3) AtG. The need for corresponding regulations results from the safety reference levels of the Western European Nuclear Regulators' Association (WENRA), to whose practical implementation Germany has committed itself as a WENRA member state (see Chapter K.5), as well as from the requirements for storage in Council Directive 2009/71/EURATOM [1F-5] on the nuclear safety of nuclear facilities. For implementation of the recommendations, there was a two-year review phase as a first step, during which the performance of a periodic safety review for two selected storage facilities was tested (Gorleben, Lingen) (see Chapter G.2.2 for details).

As a consequence of the accident at the Fukushima nuclear power plant in March 2011, the ESK conducted a stress test for nuclear fuel cycle facilities in Germany (see Chapter G.5.3 for details). The results of the stress tests are documented in two ESK statements [4-11].

In its statement of 2 July 2014 [4-13], the ESK deals with the state of preparations concerning the provision of radioactive waste packages for the Konrad repository. In this statement, relevant issues for the use of the Konrad repository are worked out, prioritised according to their relevance, and the potential for optimisation is identified, taking into account the current work progress.

On 30 October 2014, the ESK adopted its statement “Return of vitrified waste from reprocessing in other European countries – storage of the vitrified waste in on-site storage facilities on the basis of the amendment of the Atomic Energy Act on 01.01.2014 (§ 9a(2a) AtG)” [4-14]. Here, the ESK focuses on the specific features of the approval of the CASTOR® HAW28M casks under transport regulations and the question of how transportability of the casks can be ensured after expiry of the storage licence in case of failure of a primary lid seal.

In March 2015, the ESK published Guidelines for the decommissioning of nuclear facilities [4-15]. These specify the technical requirements and procedures to be applied when decommissioning facilities or parts thereof according to § 7 AtG. The guidelines take into account recommendations from the international regulations and supplement the requirements and specifications of the Decommissioning Guide [3-73] in technical terms.

In a statement of 7 May 2015 [4-16], the ESK performs a generic, facility-independent assessment of the actual condition of the waste packages on the basis of the reports submitted by the *Länder* and provides a description of the deficiencies that exist from the ESK’s point of view as regards monitoring of the waste packages and their management. The question is addressed as to the extent to which the Guidelines for the storage of radioactive waste with negligible heat generation of 10 June 2013 [4-3] prepared by the ESK have been implemented and what measures must be taken to ensure the safe storage of the waste packages also for a longer storage period.

In December 2015, the ESK adopted the Guideline on the safe operation of a disposal facility for in particular heat-generating radioactive waste [4-17]. This guideline serves to specify the "Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste” as at 30 September 2010 published by the former BMU.

In a recommendation of 17 March 2016, the ESK published "Requirements for packages for the disposal of heat generating radioactive waste" [4-18]. These specify the regulatory requirements for containers for the disposal of heat-generating radioactive waste laid down generically in the BMU Safety Requirements of 2010. From the ESK's point of view, this recommendation presents basic aspects for the future development of a more specific "container guideline".

On 12 May 2016, the ESK published a statement on the waste disposal research in Germany in terms of content and steering [4-19], which deals with the question of which research projects must be initiated from today's point of view, so that in the future alternative host rocks can be identified efficiently and be explored, assessed and compared with regard to their suitability as a disposal medium.

In addition, the “Discussion paper on the extended storage of spent fuel and other heat-generating radioactive waste” of 29 October 2015 [4-20] is to be mentioned particularly, which deals with the storage of spent fuel beyond the licensed period of 40 years in view of the provisions of the StandAG [1A-7a].

KTA safety standards

The KTA, founded in 1972, was established at the BMUB. It consists of the following five groups: representatives of the manufacturers, the plant operators, the federal and *Land* authorities, the expert organisations as well as of other authorities and representatives of general concerns, e.g. of the unions, the industrial safety and the liability insurers.

The task of the KTA is to establish safety standards and to promote their application in fields of nuclear technology where experience indicates that the experts representing the manufacturers, constructors and operators of nuclear facilities, the expert organisations and the authorities would reach a uniform opinion. The standards are developed within six subcommittees and adopted by the KTA.

The regulatory powers of the legislator and administrative action by the competent authorities are not restricted by the KTA process. It is possible to formulate necessary requirements, guidelines and recommendations and to implement them regardless of the consensual formulation of KTA safety standards.

Historically, the KTA safety standards have been developed on the basis of applicable German technical standards and regulations and on the American nuclear safety standards. The KTA safety standards contain detailed, concrete specifications of a technical nature. Regular reviews and, where necessary, amendment of adopted safety standards ensure that standards are adapted according to the state of the art in science and technology. KTA safety standards are not legally binding but, by virtue of their process of origination and their high level of detail, their practical effect is wide-ranging as specification of the necessary precautions to be taken in the light of the state of the art in science and technology.

At present (as at 12 April 2017), the KTA Programme of Standards comprises 97 standards. Of these, 28 are in the process of being revised [KTA 17]. The safety standards generally refer to nuclear power plants so that their application to facilities for spent fuel and radioactive waste management is to be examined in the individual case.

In 2015, the KTA Executive Committee decided to adapt the work of the KTA to the changed framework conditions for nuclear energy use in Germany. In the course of the coming years, a comparison of all KTA safety standards with the “Safety Requirements for Nuclear Power Plants” [3-0-1] and their “Interpretations” will be carried out. All current standard revision processes should be completed by the end of 2017. All other KTA safety standards are scheduled to be reviewed by mid-2018 for need of revision. The aim is to update all safety standards by this date such that the precautions to be taken in the light of the state of the art of science and technology to prevent damage are put in concrete terms [KTA 17].

Conventional technical standards

In addition – as is the case with the construction and operation of all technical installations – the conventional technical standards are to be applied, i.e. in particular the national standards of the German Institute for Standardisation (DIN) and the international standards of the ISO and IEC.

In this respect, the requirements of the conventional technical standards are to be referred to as a minimum standard for nuclear systems and components. Moreover, provisions of the Federation and the *Länder* relating to nuclear law shall not be affected to the extent that stricter or different requirements are made or permitted by them.

Other legal areas

When licensing nuclear facilities, legal requirements outside of nuclear safety and radiation protection legislation must also be taken into account. These include, in particular,

- the Federal Building Code [1B-18],
- the Regional Planning Act [1B-2],
- the Federal Immission Control Act [1B-3],
- the Federal Water Act [1B-5],
- the Federal Nature Conservation Act [1B-6],
- the Closed Cycle Management Act [1B-13], and
- the Environmental Impact Assessment Act [1B-14].

The following is also important regarding the exploration work for a repository and the approval procedure for a repository in deep geological formations:

- the Federal Mining Act [1B-15].

E.2.3 Licensing system

With respect to the protection against the dangers arising from radioactive substances and the control of their utilisation, the nuclear and radiation protection law requires subjecting the construction and operation of nuclear facilities as well as other facts or circumstances, such as the handling of radioactive substances, to regulatory approval. The approval requirement is laid down in various provisions, depending on the type of facility and activities involved.

- § 3 AtG: As laid down in § 3 AtG imports and exports of nuclear fuel require a licence. The BAFA decides on applications for licences. The supervision of imports and exports shall be the responsibility of the Federal Ministry of Finance or customs offices designated by it.
- § 5 AtG: Any nuclear fuel whose authorised owner cannot be ascertained or cannot be called upon, shall be placed in government custody. In the case of government custody, the necessary precautions in the light of the state of the art in science and technology to prevent damage shall be taken, and necessary protection shall be provided against disruptive action or other interference by third parties.
- § 6 AtG: The storage of nuclear fuel, including spent fuel and radioactive waste with contents of nuclear fuel requires (if the proportion of certain uranium and plutonium isotopes exceed the limits specified § 2(3) AtG) a licence according to § 6 AtG. This refers, for example, to storage facilities at the sites of nuclear power plants and the central storage facilities in Ahaus and Gorleben. The licensing authority is the BfE, whilst supervision is performed by the competent authority of the respective *Land*.
- § 7 AtG: This paragraph regulates the licensing requirements for nuclear facilities, in particular nuclear power plants. There is a restriction that no further licences shall be granted for the construction and operation of nuclear fission facilities for the commercial production of electricity and facilities for the reprocessing of spent fuel. The management of spent nuclear fuel and radioactive waste within stationary facilities for the production, treatment, processing or fission of nuclear fuel (e.g. in nuclear power plants) is generally covered by

the licences granted to such facilities according to § 7 AtG, provided these management phases are directly related to the purpose of the facility. This applies in particular to the storage of spent fuel in the spent fuel pool of the reactor and to the treatment and storage of operational waste. The pilot conditioning plant (PKA) at Gorleben has also been granted a licence pursuant to § 7 AtG. Licensing and supervision of the plant are carried out by the competent authority in the *Land* where the facility is located; in the case of the PKA, this is the *Land* of Lower Saxony.

- § 9 AtG: The treatment, processing and other use of nuclear fuel outside facilities specified in § 7 AtG, e.g. the handling of nuclear fuel on a laboratory scale for research purposes, requires a licence pursuant to § 9 AtG. The respective *Land* authority shall be responsible for licensing and supervision.

- § 9b AtG: As defined in § 9a(3) AtG, first sentence, the Federation shall establish facilities for the safekeeping and disposal of radioactive waste. These facilities require plan approval according to § 9b AtG. In the cases where the site was determined by federal law, a licence shall substitute the plan approval, since interests to be weighed against each other will have already been reviewed and assessed in the statutory site selection procedure. As defined in § 23d AtG, the BfE shall be responsible for nuclear waste management. According to § 58(2) and (3 AtG, the *Länder* shall be responsible for the Konrad repository until granting of the approval of commissioning by the nuclear supervisory authority and for the Morsleben repository for radioactive waste (ERAM) until the plan approval decision on decommissioning will be enforceable. The construction, the later operation and decommissioning of disposal facilities as well as the operation and closure of the Asse II mine will in the future be the responsibility of the BGE, as a third party in terms of § 9a(3) AtG, second sentence. In anticipation of this, there has already been a first order by the BMUB the purpose of which is to create the material, personnel and organisational conditions so that the BGE can perform its tasks step by step starting in 2017. To a certain extent, the BGE is also empowered to carry out sovereign tasks on its own behalf (entrusted with sovereign tasks). It is planned that the human and material resources necessary for the performance of tasks in the long term are transferred from the BfS, the Asse-GmbH and the DBE to the BGE. The surveillance of construction and operation of disposal facilities will in the future be the responsibility of the BfE.

- § 7 StrlSchV [1A-8]: The handling of radioactive substances according to § 2(1) AtG or of nuclear fuel according to § 2(3) AtG requires a licence according to § 7 StrlSchV unless already covered by one of the aforementioned licences. This category includes, in particular, the waste collecting facilities of the *Länder*, storage facilities for radioactive waste at research centres and conditioning facilities. Licensing and supervision are the tasks of the competent *Land* authority.

The licensing system particularly with regard to decommissioning is dealt with in the reporting on Article 26.

Responsibilities relating to the licensing of nuclear facilities are summarised in Table E-1. It shows that for licensing and supervision of the different facility types and activities, in some cases different authorities are responsible. Uniform application of the legal requirements and a harmonised licensing practice is ensured by the BMUB's supervision of legality and appropriateness described more detailed in Chapter E.2.1.

Table E-1: Responsibilities relating to the approval and supervision of nuclear facilities and the handling of radioactive waste in the Federal Republic of Germany

Material	Activity	Legal basis	Licensing	Supervision	Facilities (examples)
Nuclear fuel and waste containing fissile material	Construction and operation	§ 7 AtG	*Land* authority	*Land* authority	PKA, VEK
	Treatment, use	§ 9 AtG	*Land* authority	*Land* authority	Activities outside of facilities governed by § 7 AtG (e.g. laboratory-scale handling of nuclear fuel for research purposes)
	Storage	§ 6 AtG	BfE	*Land* authority	Gorleben, Ahaus, on-site storage facilities
	Import and export	§ 3 AtG	BAFA	Federation	-
Other radioactive substances acc. to § 2(1) AtG, nuclear fuel acc. to § 2(3) AtG (e.g. waste with low fissile material content)	Handling, e.g. storage	§ 7 StrlSchV[1)]	*Land* authority	*Land* authority	Collecting facilities of the *Länder*, storage facilities, conditioning facilities
Radioactive waste with negligible heat generation	Disposal	§ 9b AtG	BfE (for Konrad and ERAM *Land* authority still competent as a transitional provision)	BfE	ERAM, Konrad repository
Heat-generating radioactive waste	Disposal	§ 9b(1a) AtG	BfE	BfE	-

1) Unless there is a licence according to §§ 6, 7, 9 or 9b AtG already extending to the activity.

An approval according to the AtG may only be granted if the licensing conditions laid down in the corresponding sections of the Act are met by the applicant. This includes, in particular, the required precautions against damage in accordance with the state of the art in science and technology.

Furthermore, it should be noted that any handling of radioactive material is subject to the binding provisions on supervision and protection outlined in the StrlSchV. The StrlSchV also includes regulations on the designation of responsible individuals by the approval holder and the dose limits of radiation exposure for plant personnel and the general public.

Approvals for nuclear facilities may be subject to certain conditions to ensure safety. The operation and ownership of, essential modifications to or decommissioning of a nuclear facility and the handling of radioactive waste without the necessary approval are offences liable to prosecution.

Except for nuclear fuel storage facilities licensed by the BfE under § 6 AtG [1A-3], the licensing of nuclear facilities is the responsibility of the respective *Länder*. In the *Länder*, ministries are the supreme authorities responsible for licensing according to the AtG (§§ 7 and 9 AtG). Granting of licences according to the StrlSchV (handling of radioactive waste, collecting facilities of the *Länder*) can be transferred to subordinate authorities (e.g. trade supervisory offices). The Federation supervises the implementation of the nuclear and radiation protection law by the *Länder* (federal supervision). In particular, it has the right to issue binding directives to the *Land* concerned on factual and legal issues in each individual case.

The actual details and procedure of licensing in accordance with § 7 AtG [1A-3] are specified in the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10]. It deals specifically with the application procedure, the submission of supporting documents, participation of the general public and the option of splitting the procedure into several stages (partial licences). Furthermore, it also addresses the environmental impact assessment [1B-14] and the consideration of other licensing requirements (e.g. non-radioactive emissions into the air or discharges into water). The AtVfV is also applied in the case of other nuclear licensing and plan approval procedures (according to §§ 6 and 9b AtG, respectively. The option of splitting the licensing procedure into several phases with individual partial licences is usually taken up for large-scale facilities which take longer to be built and commissioned. The advantage is that the most recent state of the art in science and technology can be applied in each individual procedural step. For example, the first step may include the licensing of the site, the safety concept and the most important structures. Further steps might be the installation of safety-relevant systems, nuclear start-up and full power operation.

In accordance with § 20 AtG, the competent authorities may consult authorised experts on all technical or scientific matters related to regulatory approval and supervision. However, the authority is not bound by the assessments of their authorised experts.

The current nuclear liability regulations have transposed the Paris Convention on Third Party Liability in the Field of Nuclear Energy [1E-11], amended by the Brussels Supplementary Convention [1E-12], into national law. Details of the required financial security are regulated by a statutory ordinance [1A-11]. In Germany, this means that operators are generally required to take out liability insurance policies for a maximum financial sum specified in the individual nuclear licensing procedure.

In the following, examples are given for the procedures according to §§ 6, 7 and 9b AtG [1A-3].

In contrast to licences according to §§ 6 or 7 AtG, the construction, operation and closure of disposal facilities for radioactive waste are subject to a plan approval procedure according to § 9b AtG, unless in the cases where the site was determined by federal law, a licence shall substitute the plan approval (§ 9b(1a) AtG). This clearly shows that the plan approval procedure is a special type of procedure by which projects are considered in relation to the environment, taking into account all public and private interests affected. Accordingly, the effects of approval, concentration, replacement, creation of a legal situation and toleration are characteristic for the plan approval decision.

As a central licensing provision of the AtG (for facilities), special attention is to be paid to the licensing for facilities for production, processing, treatment or fission of nuclear fuel or for the reprocessing of spent fuel as well as for decommissioning, safe enclosure and dismantling according to § 7 AtG. Since § 6 AtG does not represent a licence for a facility but an activity-related licence for the storage of nuclear fuel, this issue will be outlined below for differentiation and a better understanding.

Licence for the storage of nuclear fuel according to § 6 AtG

§ 6 AtG [1A-3] is not referring to a licence for a facility, as are for example licences according to § 7 AtG, but a so-called activity-related licence. Here, the activity of storage of nuclear fuel is permitted, i.e. first of all its storage (in contrast to disposal according to § 9b AtG) at a particular location, but also activities necessary for it (e.g. taking over and preparation of casks, transportation to the cask position, maintenance work and other common operations). This storage does neither require a comprehensive nuclear construction and operation licence nor a formal plan approval procedure. For the construction of such a storage facility, the building laws of the respective *Länder* apply. The construction licence is to be limited regarding the use of the building insofar as it does not contain a final decision binding for third parties on the protection against nuclear-specific risks. This issue is subject to examination by the nuclear regulatory authorities responsible for it.

The licence according to § 6 AtG is a bound decision which means that it is to be granted without discretion if the conditions stated in § 6(2) AtG are fulfilled. The corresponding conditions largely correspond to those of § 7(2) AtG, with the exception of the "knowledge of persons involved" within the meaning of § 7(2)(2) AtG, and the "conflict with overriding public interests" within the meaning of § 7(2)(6) AtG.

The nuclear licensing procedure for facilities according to § 7 AtG

According to § 7 AtG [1A-3], construction, operation or ownership of a stationary facility for the production, processing, treatment or fission of nuclear fuel, an essential modification of such facility or its operation and also decommissioning, safe enclosure and dismantling are subject to licensing. A licence may only be granted if the licensing requirements stated in § 7(2) AtG are complied with, i.e. if

- the necessary precautions have been taken in the light of the state of the art in science and technology to prevent damage,
- the necessary protection has been provided against disruptive action or other interference by third parties,
- the choice of the site of the facility does not conflict with overriding public interests, in particular as regards its environmental impacts.

These requirements for licensing also constitute assessment criteria for supervision during operation.

The undefined legal terms used by the legislator, such as the "the necessary precautions in the light of the state of the art in science and technology", were chosen to facilitate a dynamic further development of the precautions according to the latest state of the art. Thus, legislation largely left it to the executive – be it by way of ordinances according to the relevant authorisations, be it in case of individual decisions also under consideration of the non-mandatory guidance instruments – to decide on the kind and, in particular, the extent of risks to be accepted or not to be accepted (see Chapter E.2.2 for details on the hierarchical structure of the regulations). The AtG does not include specific regulations on the procedure for the assessment of such risks.

Licence application

The licence application is submitted in written form to the competent licensing authority of the *Land* in which the nuclear facility is to be constructed. The licence application is accompanied by documents containing all the relevant data required for evaluation purposes. The documents which should be enclosed with the application are listed in the AtVfV. The required format is further specified in guidelines.

§ 3 AtVfV defines the kind and scope of the documents. Accordingly, the application shall be accompanied by the documents needed to examine the licensing prerequisites, in particular

1. a safety analysis report describing the impacts of the project in terms of nuclear safety and radiological protection which are material with respect to the decision concerning the application and enabling third parties in particular to see whether or not their rights may be affected by the impacts associated with the facility and its operation. For this purpose, the safety analysis report shall contain the following information to the extent required for the assessment of the admissibility of the project:

   a) a description of the facility and its operation, accompanied by site plans and survey drawings;

   b) a description and explanation of the concept (basic design features), the safety-related design principles and the function of the facility, including its operating and safety systems;

   c) a description of the precautions provided for in order to comply with § 7(2)(3) AtG, i.e. the necessary precautions to be been taken in the light of the state of the art in science and technology to prevent damage resulting from the erection and operation of the facility;

   d) a description of the environment and its constituents;

   e) data concerning the direct radiation and discharge of radioactive materials related to the facility and its operation, including releases from the facility during accidents as defined in §§ 49 and 50 StrlSchV (design basis accidents);

   f) a description of the effects which the direct radiation and discharge of radioactive materials referred to in subpara. e above have on the properties to be protected pursuant to § 1a, including interactions with other materials;

2. supplementary plans, drawings and descriptions of the facility and its components;

3. information concerning measures provided for the facility and its operation against interference and other intervention by third parties, according to § 7(2)(5) AtG;

4. information enabling the examination of the reliability and expertise of the persons responsible for the construction of the facility and the management and supervision of its operation;

5. information enabling a verification as to whether the persons otherwise engaged in the operation of the facility possess the necessary knowledge in accordance with § 7(2)(2) AtG;

6. a schedule containing all the data relevant to the safety of the facility and its operation, the measures to be taken in the event of incidents or damage, and an outline plan of the tests provided for safety-related components of the facility (safety specifications);

7. proposals for financial security to cover the legal liability to pay compensation;

8. a description of the radioactive residues accumulating as well as data concerning the measures intended to be taken

   a) for the prevention of any accumulation of residual radioactive materials;

   b) for the safe utilisation of accumulated residual radioactive materials and dismantled or dismounted radioactive components of the facility;

   c) for the disposal of residual radioactive materials or dismounted radioactive components in the form of radioactive wastes in a controlled manner, including their intended treatment, as well as for the anticipated storage of radioactive wastes until their disposal;

9. data relating to other environmental impacts of the project which are required for the examination pursuant to § 7(2)(6) AtG with respect to approval decisions which, in individual cases, may be included in the licensing decision, or for decisions to be taken by the licensing authority in accordance with provisions relating to the conservation of nature and the maintenance of landscapes.

Based on these data it is to be examined whether the choice of the site of the facility does not conflict with overriding public interests, in particular as regards its environmental impacts.

Furthermore, a short description of the planned facility, including information on the estimated impacts for the population and the environment, should be included with the licence application for the purpose of participation by the general public.

Examination of the application

On the basis of the submitted documents, the licensing authority examines whether or not the licence prerequisites have been met. All federal, *Länder*, local and other regional authorities whose jurisdiction is affected are to be involved in the licensing procedure, including in particular the authorities responsible for civil engineering, water, regional planning and off-site disaster control. Given the broad scope of the safety issues to be examined, it is common practice to engage technical expert organisations to support the licensing authority in the evaluation and examination of the application documents. These organisations prepare expert reports outlining whether or not the requirements regarding nuclear safety and radiation protection have been met. They have no autonomous decision-making powers. The licensing authority assesses and decides on the basis of its own judgment. The authority is not bound by the findings of their authorised experts.

Within the framework of federal executive administration, the BMUB may submit a statement from the point of view of federal supervision before the licence is granted. In performing its function of federal supervision, the BMUB consults its advisory bodies, the RSK, the SSK, the ESK as well as technical expert organisations, such as the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH, for advice and technical support. The *Land* licensing authority must take the BMUB's statement into account when making its decision.

Environmental impact assessment

The Environmental Impact Assessment Act [1B-14], in conjunction with the AtG and the AtVfV [1A-10] based on it, regulates the need to conduct an environmental impact assessment and its procedure within the nuclear licensing procedure for the construction, operation and decommissioning of a nuclear facility to be licensed according to § 7 AtG [1A-3] or for an essential modification of the facility or its operation. An environmental impact assessment (EIA) determines and describes in a report what impact a project will have on humans (including human health), on animals, plants, biodiversity, soil, water, ambient air, the climate, the landscape and cultural goods. The public and specialist authorities, as well as citizens and authorities in neighbouring countries that may be affected, may express comments and opinions on the report.

According to § 3(2) AtVfV, the licence application shall be accompanied by the following additional documents In the case of projects requiring an EIA:

1. a survey of the most important alternative technological processes examined by the applicant, including a statement of the major reasons for the selection, insofar as such a statement may be of importance for the assessment of the admissibility of the project under § 7 AtG;

2. references to difficulties which arose when the data for the assessment pursuant to § 1a were collected, in particular insofar as these difficulties are based on a lack of knowledge and examination methods or on technological gaps.

The competent authority performs a final evaluation of the environmental impacts, which provides the basis for a decision on the project's admissibility with regard to effective environmental protection.

Germany is a contracting party to the "Convention on Environmental Impact Assessment in a Transboundary Context" (Espoo Convention) [1E-1-1] of 1991. According to this Convention, the authorities and the public in other possibly affected neighbouring countries must be involved as part of a transboundary EIA before a project is approved, if the project can have transboundary environmental impacts. Germany applies the participation procedure vis-à-vis all its neighbours.

Public participation

The licensing authority involves the general public in the licensing procedures, including in particular those citizens who might be affected by the planned facility. Details are regulated in the AtVfV [1A-10].

According to § 4 AtVfV, the project is published in the official gazette of the licensing authority and in local daily newspapers once the documents to be submitted for public display are complete. According to § 5 AtVfV, this announcement should, among other things, indicate where and when the application will be available for public inspection, state that objections, if any, are to be brought before the competent body within the specified period, set the date of a hearing, or indicate that a hearing shall take place.

According to § 6 AtVfV, the application, the safety analysis report, a brief description of the project and – if the project requires an EIA – information on radioactive residues and other environmental impacts of the project, as described under § 3(8) and (9) AtVfV, and the documents according to § 3(2) AtVfV are to be laid out for public inspection for a period of two months.

According to § 7 AtVfV, objections may be raised in writing or for transcript at the competent offices.

The public hearing is regulated in §§ 8 to 13 AtVfV. It serves to discuss any objections that have been duly raised with the applicant and those having raised the objections, insofar as this may be of importance for the examination of the approval prerequisites. Any individuals who have raised objections are to be given the opportunity to explain them.

The licensing authority takes these objections into account in its decision-making process and states the reasons for the decision.

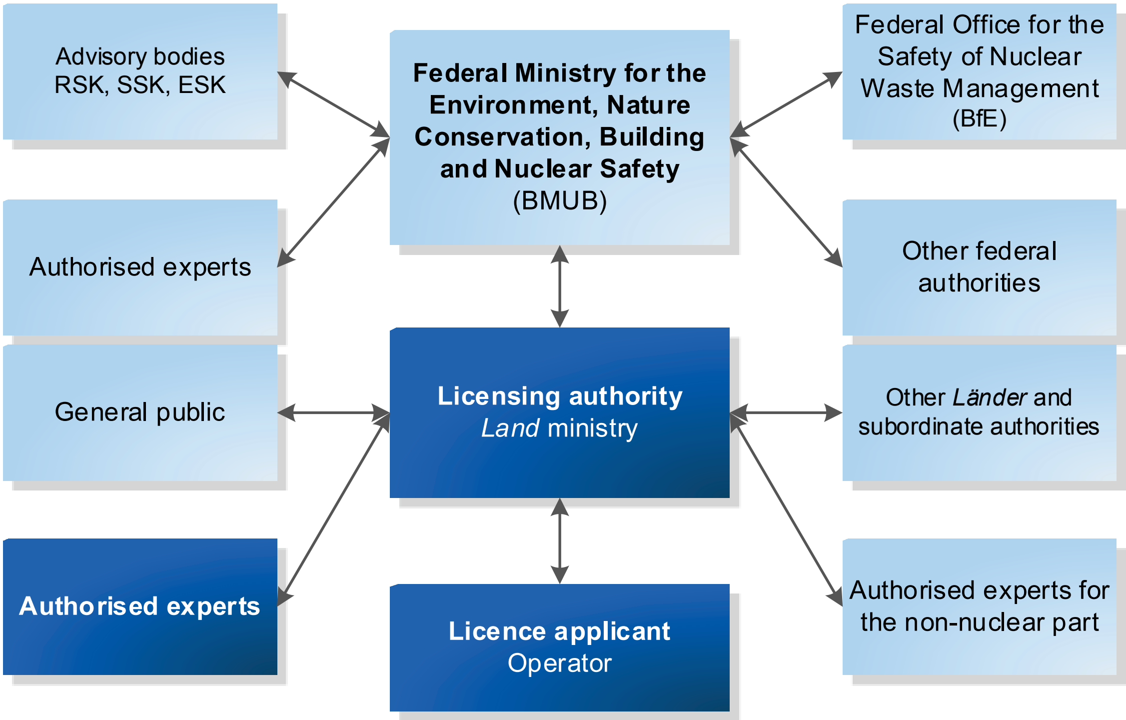
In case of material amendments to a nuclear licence, public participation may not be necessary if the modification applied has no adverse effects for the population.

Licensing decision

The final decision of the licensing authority is based on the entirety of application documents, evaluation reports by the authorised experts, the opinion of the BMUB, the opinions of the authorities involved, and the findings from objections raised in the public hearing. One prerequisite for the legality of this decision is that all procedural requirements of the AtVfV [1A-10] must have been observed. Action may be brought against the decision of the licensing authority before an administrative court by each citizen as far as at least the potential violation of own rights to life, health and property is claimed. Appeals, if applied for and admitted, may be brought up to the Federal Administrative Court. In the case of a licence with immediate enforcement, a court action cannot prevent use being made of the licence. However, action may be brought against immediate enforcement.

The interaction between the various authorities and organisations involved in the nuclear licensing procedure and the participation of the general public is shown in Figure E-2. This creates a broad and differentiated decision-making basis which allows all interests to be taken into account when reaching a final decision.

Figure E-2: Parties involved in the nuclear licensing procedure (taking the procedure according to § 7 AtG as an example)



Plan approval procedure under nuclear law according to 9b AtG for federal facilities for the safekeeping and disposal of radioactive waste

According to § 9a(3) AtG [1A-3], the Federation shall establish facilities for the safekeeping and disposal of radioactive waste. According to § 9b(1) AtG, the construction, operation and decommissioning of such facilities require plan approval. Upon application, the project may be carried out in several steps and, accordingly, partial plan approval decisions may be issued. In the cases where the repository site was determined by federal law, a licence shall substitute the plan approval decision (§ 9b(1a) AtG).

With the entry into force of the Act on the Reorganisation of the Organisational Structure in the Field of Disposal of 30 July 2016 [1A-30], the BGE was established as a third party in terms of § 9a(3) AtG, second sentence. In the future, the BGE will bundle the operator and operational management tasks in a publicly owned company under private law.

The BfE is responsible for plan approval and licensing according to § 9b AtG and their withdrawal. This, however, currently does not apply to the Konrad repository until granting of the approval of commissioning by the nuclear supervisory authority and to the ERAM until the plan approval decision on decommissioning will be enforceable. In both cases, the responsibility will rest with the competent supreme *Land* authority until then. The plan approval for the closure of the Asse II mine is also outside the competence of the BfE in accordance with § 57b(9) AtG.

The approval for a disposal facility may only be granted if the requirements stated § 7(2)(1), (2), (3) and (5) AtG have been fulfilled. Moreover, approval for a disposal facility shall be refused if

- the construction, operation or closure of the proposed facility suggest that the common welfare will be impaired and that such impairment cannot be prevented by restrictions and obligations, or
- the construction, operation or closure of the facility conflicts with other provisions of public law, in particular with respect to the environmental impact of the facility.

The main peculiarity of the plan approval procedure is the concentration of all areas of law within a single procedure. Thus, the plan approval decision covers, unlike other nuclear procedures, almost all other licences required, e.g. under the terms of building legislation or nature conservation legislation. Exceptions to this result from § 9b(5)(3) AtG and the Federal Water Act (WHG). Accordingly, plan approval does not extend to the legitimacy of the project under the provisions of mining and subsurface storage law, which requires other procedures. As far as permits are required according to water legislation, they are also decided on separately according to § 19 WHG. Exceptions are decided on by the competent authority. Moreover, the plan approval procedure according to § 9b(5)(1) AtG also provides for public participation.

The legitimacy of the project regarding all public interests affected by it will also be verified by a licence pursuant to § 9b(1a) AtG. Apart from the licence, all other decisions made by the authorities, especially licences issued under public law, concessions, permits, permissions, consents and plan approval decisions shall not be required with the exception of permits and concessions relating to water law and of decisions regarding the legitimacy of the project according to the provisions of the mining and subsurface storage law.

Contrary to licensing pursuant to § 7 AtG, liability provisions are not in place since the State itself shall be responsible for such a facility. § 13(4) AtG explicitly states that the Federation and the *Länder* are not obliged to make liability provisions.

The parties involved in the approval procedure for a repository and in repository supervision and surveillance are summarised in Figure E-3 and Figure E-4.

Figure E-3: Parties involved in the nuclear approval procedure for a repository

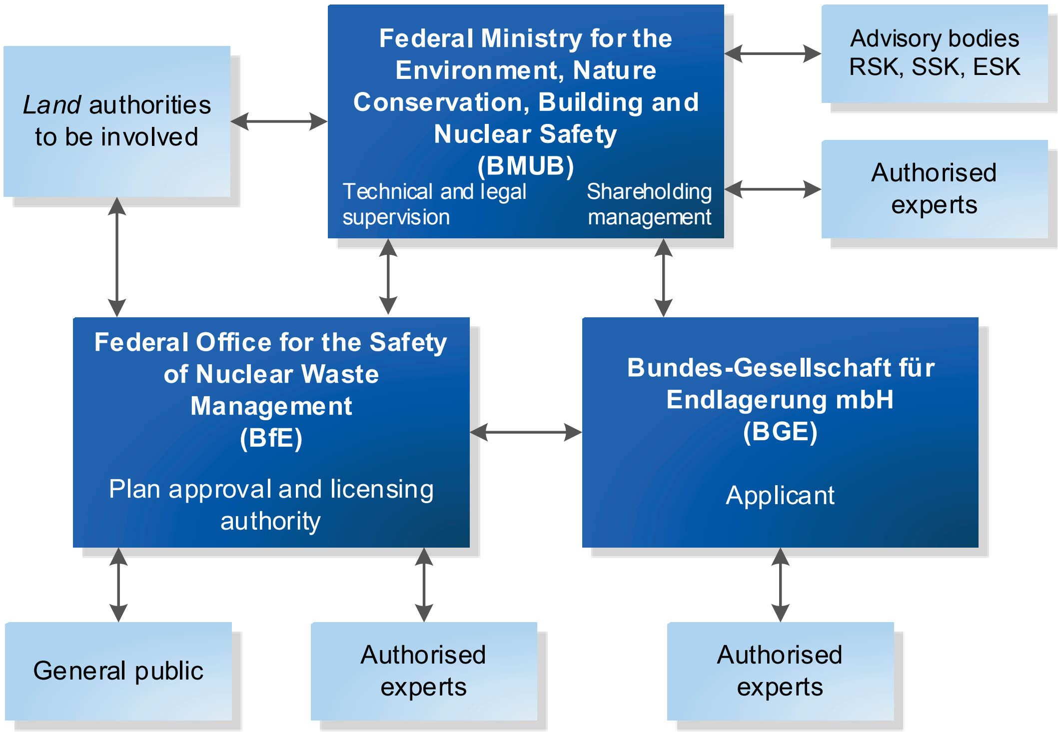
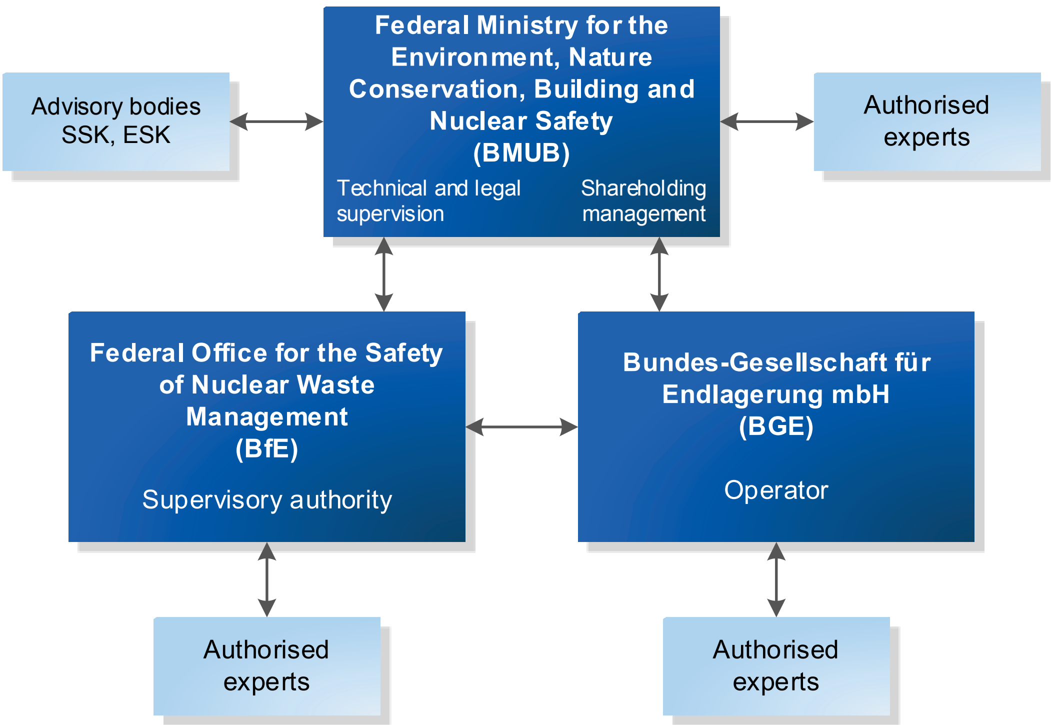


Figure E-4: Parties involved in repository supervision and surveillance



E.2.4 System of prohibiting the operation of a facility without licence

Prohibition of the operation of a spent fuel or radioactive waste management facility without a licence is derived from the requirements contained in the Penal Code, the Atomic Energy Act and the nuclear ordinances. These issues are addressed in more detail in the reporting on Article 19(2)(v) in Chapter E.2.6.

E.2.5 Regulatory inspection and assessment (supervision)

Continuous regulatory supervision

Throughout their operating lives, including construction and decommissioning, nuclear facilities are subject to continuous regulatory supervision, after having been granted the necessary approval, according to § 19 AtG [1A-3] – the facilities for disposal are supervised by the BfE – and the associated nuclear ordinances. As with the licensing procedure, a distinction is made between the matters of handling pursuant to §§ 6 and 9 AtG, and the facilities licensed pursuant to § 7 AtG and the disposal facilities which are subject to plan approval or licensing according to § 9b AtG.

Where nuclear facilities or the handling of nuclear fuel has been licensed according §§ 6, 7 or 9 AtG, the *Länder* carry out nuclear supervision. In this respect, they are also acting on behalf of the Federation, i.e. the Federation has the right to issue binding directives on factual and legal issues in each individual case. As in the licensing procedure, the *Länder* are assisted by independent authorised experts. The same applies to the handling of other radioactive substances according to § 7 StrlSchV [1A-8].

As in licensing, the primary objective of regulatory supervision is to protect the general public, the environment and the persons employed in these facilities against the hazards associated with the operation of the facility.

In particular, it is the duty of the supervisory authority to monitor

- compliance with the provisions, obligations and other ancillary provisions imposed by the licensing notices,
- compliance with the requirements of the Atomic Energy Act, the nuclear ordinances and other nuclear safety standards and guidelines, and
- compliance with supervisory orders issued, if any.

To ensure safety, the supervisory authority monitors, also with the aid of its authorised experts or by other authorities,

- compliance with the operating procedures,
- the performance of in-service inspections of safety-relevant components and systems,
- the evaluation of reportable events,
- the implementation of modifications to the nuclear facility or its operation,
- radiation protection monitoring of the personnel,
- radiation protection monitoring in the vicinity of the nuclear facility,
- compliance with the authorised plant-specific limits for radioactive discharge,

- the measures against disruptive action or other interference by third parties,
- the trustworthiness, technical qualification and maintenance of the qualification of the responsible persons as well as of the knowledge of persons otherwise engaged in the operation of the facility,
- the quality assurance measures.

The supervisory authority and the authorised experts consulted by it have access to the facility at any time and are entitled to carry out the necessary examinations and to demand information (see § 19(2) AtG [1A-3]).

Contrary to this regulatory supervision by the respective *Land* for licences according to §§ 6, 7 or 9 AtG regulated in § 19 AtG, other regulations apply for regulatory supervision with regard to federal facilities for the safekeeping and disposal of radioactive waste. The responsibility for the construction and operation of these facilities rests with the BGE. According § 23d(1) AtG, first sentence, the BfE shall be responsible for plan approval and licensing of the facilities. According to § 58 AtG, the responsibility with regard to approval will rest with the supreme *Land* authorities designated by the *Land* governments for the Konrad repository until granting of the approval of commissioning by the nuclear supervisory authority and for the ERAM until the plan approval decision on decommissioning will be enforceable. According to § 23d(2) AtG, first sentence, the BfE shall also be responsible for the supervision of facilities of the Federation pursuant to § 9a(3) AtG, first sentence (facilities for the safekeeping and disposal of radioactive waste) and of the Asse II mine pursuant to § 19(5) AtG. The comprehensive technical and legal supervision of the BfE is exercised by the BMUB to whose portfolio the BfE belongs.

Furthermore, the BfE monitors the implementation of the site selection procedure according to § 19(1) to (4) AtG.

Reporting obligations

The legal basis for the documentation and reporting of radioactive waste is § 70 StrlSchV [1A-8] (Record keeping and notification). It requires communicating to the competent authority extraction, production, acquisition, transfer and other dispositions of radioactive substances within one month, specifying type and activity. In addition, the inventory is reported annually. The competent authority is entitled to verify the correctness of record keeping at any time. It may also exempt from the obligations of record keeping and reporting wholly or in part.

Much more detailed provisions were included in the Guideline on the control of radioactive waste with negligible heat generation of the former BMU which is not handed over to a *Land* collecting facility (Waste Control Guideline) [3-59]. This guideline entered into force in 1989. The main contents were adopted into the new StrlSchV of 2001. The new Waste Control Guideline published in 2008 [3-60] only contains those aspects that are not covered by the StrlSchV and has been extended to radioactive residues.

According to §§ 72 and 73 StrlSchV, the operators and those handling nuclear fuel are required to document the arising and whereabouts of waste and to submit the documentation to the authorities. The documentation is prepared by the operators with the help of various computerised systems, such as the Waste Flow Tracking and Product Control System (AVK) of the GNS Gesellschaft für Nuklear-Service mbH (GNS). Another system is the Residue Flow Tracking and Control System (ReVK) of TÜV Rheinland ISTec GmbH or the documentation, tracking and administration of residues and waste arising e.g. in connection with the operation and dismantling of nuclear facilities. As these systems also fulfil other tasks than merely documentation duties, they are much more detailed than required by the StrlSchV.

The BGE queries the inventories of radioactive waste in Germany as well as the existing storage capacities and their occupancy with the help of standardised form sheets (computer-based) as at reporting date 31 December on an annual basis. The forms completed by the waste proprietors are then sent back via the competent *Land* authority to the BGE and are evaluated there.

An obligation to report to the corresponding supervisory authority also exists for measures taken by the operators to utilise any radioactive residues without detrimental effects or dispose them of as radioactive waste in a controlled manner in accordance with § 9a(1) AtG [1A-3]. In particular, proof is to be furnished that adequate precautions have been taken in order to comply with the obligations for already existing and for future spent fuel as well as for the waste to be returned from reprocessing (§ 9a(1a) AtG). This proof is to be provided annually. For the purposes of controlled disposal of spent fuel and radioactive waste, proof is to be furnished showing that safe storage in storage facilities is ensured until such time as it is transferred to a facility for disposal (§ 9a(1b) AtG). Realistic plans have to be submitted with regard to the expected need for storage capacity. The availability of storage capacity as needed is to be demonstrated for the following two years. If non-detrimental utilisation of the plutonium from reprocessing is intended, it is also necessary to prove that the reuse of the plutonium in the nuclear power plants is ensured (§ 9a(1c) AtG). This proof shall be deemed to be furnished if realistic plans for reprocessing, fuel fabrication and fuel use have been provided and their feasibility has been demonstrated. As for uranium from reprocessing, its safekeeping is to be demonstrated by realistic planning of sufficient storage capacities (§ 9a(1d) AtG).

In order to give the BMUB an overall survey of the management of the spent fuel and the nuclear fuels to be utilised, the operators' waste management records are submitted to the BMUB by the *Länder*.

All safety-related events in facilities licensed according to § 7 AtG [1A-3] and during handling of nuclear fuel according to § 6 AtG have to be reported to the authorities in accordance with § 6 Nuclear Safety Officer and Reporting Ordinance (AtSMV) [1A-17]. A corresponding reporting obligation for other facilities ensues from § 51(1) StrlSchV. The regulations and procedures relating to reportable events and their evaluation are described in the reporting on Article 9 (see Chapter G.6.5 for details).

E.2.6 Enforcement of provisions and terms of the licences

Enforcement by regulatory order, particularly in urgent cases

According to § 19 AtG, the supervisory authority may order that a situation be discontinued which is contrary to the provisions of the Atomic Energy Act, the nuclear statutory ordinances, or to the terms and conditions of the licence, or to any subsequently imposed obligation, or which may constitute a hazard to life, health or property. Depending on the specific circumstances of the individual case it may order, in particular, that

- certain protective measures shall be taken,
- that operation may only be continued with restrictions or subject to certain conditions, or
- operation is to be discontinued temporarily until the causes of an event are clarified and necessary remedial actions against recurrence are taken.

In case of non-fulfilment of the licensing provisions or the supervisory orders, the supervisory authority of the respective *Land* is authorised to enforce their fulfilment by coercive administrative measures in accordance with the general provisions applicable to the police authorities of the *Land*.

Enforcement by modification or revocation of the licence

Under certain conditions, as stipulated in § 17 AtG, obligations for ensuring safety may be decreed by the nuclear licensing retrospectively. In case a considerable hazard is suspected from the nuclear facility endangering the persons engaged at the facility or the general public, and if this hazard cannot be eliminated within a reasonable period of time by means of appropriate measures, then the licensing authority must revoke the issued licence. Revocation is also possible if certain licence prerequisites cease to be met at a later date, or if the operator violates legal regulations or decisions by the authorities.

In addition, the Criminal Code (StGB) [1B-1], the AtG [1A-3] and the nuclear statutory ordinances provide for sanctions to prosecute violations.

Criminal offences

Any violation that is classed as a criminal offence is dealt with in the StGB. Whosoever, e.g.,

- operates, possesses, substantially modifies or decommissions a nuclear facility without the required licence,
- knowingly constructs a defective nuclear facility,
- handles nuclear fuel or waste containing fissile material without the required licence,
- releases ionising radiation or causes nuclear fission processes capable of harming the life or limb of another person,
- procures or manufactures nuclear fuel, radioactive material or other equipment for himself with the intent of performing a criminal offence

shall be liable to imprisonment or a fine.

Administrative offences

§§ 46, 49 of the Atomic Energy Act (AtG) and the associated ordinances deal with administrative offences and provide for the imposition of fines on the perpetrators. An administrative offence is deemed to have been committed by anyone who, e.g.,

- constructs a nuclear facility without a licence,
- acts in violation of a regulatory order or provision,
- handles radioactive material without a valid licence permit,
- as the ultimately responsible person fails to ensure compliance with the protective and surveillance regulations of the StrlSchV. (The AtG and associated ordinances require that the individuals who are ultimately responsible for the handling of radioactive material, for the operation of nuclear facilities or for their supervision should be named.)

For administrative offences, fines may be imposed of up to 50,000 euros. A legally effective fine against a person may cast doubt on the personal trustworthiness that was a prerequisite for the licence and may therefore require the removal of such individuals from office (see reporting on Article 21 of the Convention).

Experiences

Due to the intensive regulatory supervision (see Chapter E.2.5 for details) of planning, construction, commissioning, operation and decommissioning of nuclear facilities in Germany, inadmissible states and conditions are generally identified in advance and their removal ordered and performed before taking of measures provided by law becomes necessary, such as obligations, orders and proceedings relating to an administrative or criminal offence.

The instruments presented have proved to be effective since, as a rule, they ensure that the authorities have appropriate sanction possibilities and powers for the enforcement of provisions and regulations, if required.

E.2.7 Responsibilities

The management of spent fuel and radioactive waste is based on the polluter-pays principle. According to § 9a(1) AtG [1A-3], the producers of radioactive residues are required to ensure that these are utilised without detrimental effects or are disposed of as radioactive waste in a controlled manner. This also means that, as a general principle, the producers are responsible for the conditioning and storage of the spent fuel and the radioactive waste. With the delivery of radioactive waste to a *Land* collecting facility, the ownership is transferred to this facility. Thus, the responsibility for conditioning is assumed by the operator of the *Land* collecting facility.

According to § 9a(2) AtG, anyone possessing radioactive waste must deliver it to a repository or to a *Land* collecting facility.

According to § 9a(3) AtG, the *Länder* shall establish *Land* collecting facilities for the storage of radioactive waste produced within their territory. Radioactive waste with negligible heat generation from research, medicine and industry is delivered to these facilities. The producers of radioactive waste from the use of nuclear energy for electricity production are responsible for its conditioning and storage unless it was delivered as radioactive waste properly packaged pursuant to § 2 of the Waste Management Transfer Act – upon fulfilment of the requirements – to a third party commissioned by the Federation, i.e. the BGZ Gesellschaft für Zwischenlagerung mbH, who will then be responsible for further storage.

According to § 9a(3) AtG, the Federation shall establish facilities for the disposal of radioactive waste. The Act on the Reorganisation of the Organisational Structure in the Field of Disposal (EndLaNOG*)* [1A-30], which entered into force on 30 July 2016, concentrates operation and supervision of disposal, each in one hand. Accordingly, the operator and operational management tasks are transferred to a publicly owned company under private law, the BGE and bundled there. Its future privatisation shall be excluded. The BGE thus takes over the operational tasks of the search for a site, the construction, the operation and the closure of repositories as well as of the Asse II mine.

The regulatory functions of supervision and licensing in the field of disposal are concentrated at a single authority, the BfE, insofar as they are not performed by the *Länder*.

According to the Act on the Reorganisation of Responsibility in Nuclear Waste Management [1A-31], entered into force on 16 June 2017, the implementation and financing of storage and disposal for the cases regulated by law will in the future be the responsibility of the Federation once the relevant prerequisites are given or have been executed. The funds for nuclear waste management were made available to the Federation by the operators and transferred to a fund (see Chapter E.2.2 for details on the Act on the Reorganisation of Responsibility in Nuclear Waste Management). Implementation and financing of decommissioning and dismantling of nuclear power plants as well as proper packaging of radioactive waste remain the responsibility of the operators. The use of disposal facilities and *Land* collecting facilities is generally (re-)financed through costs (fees and expenses) and charges which have to be paid by the party delivering radioactive waste.

E.3 Article 20: Regulatory body

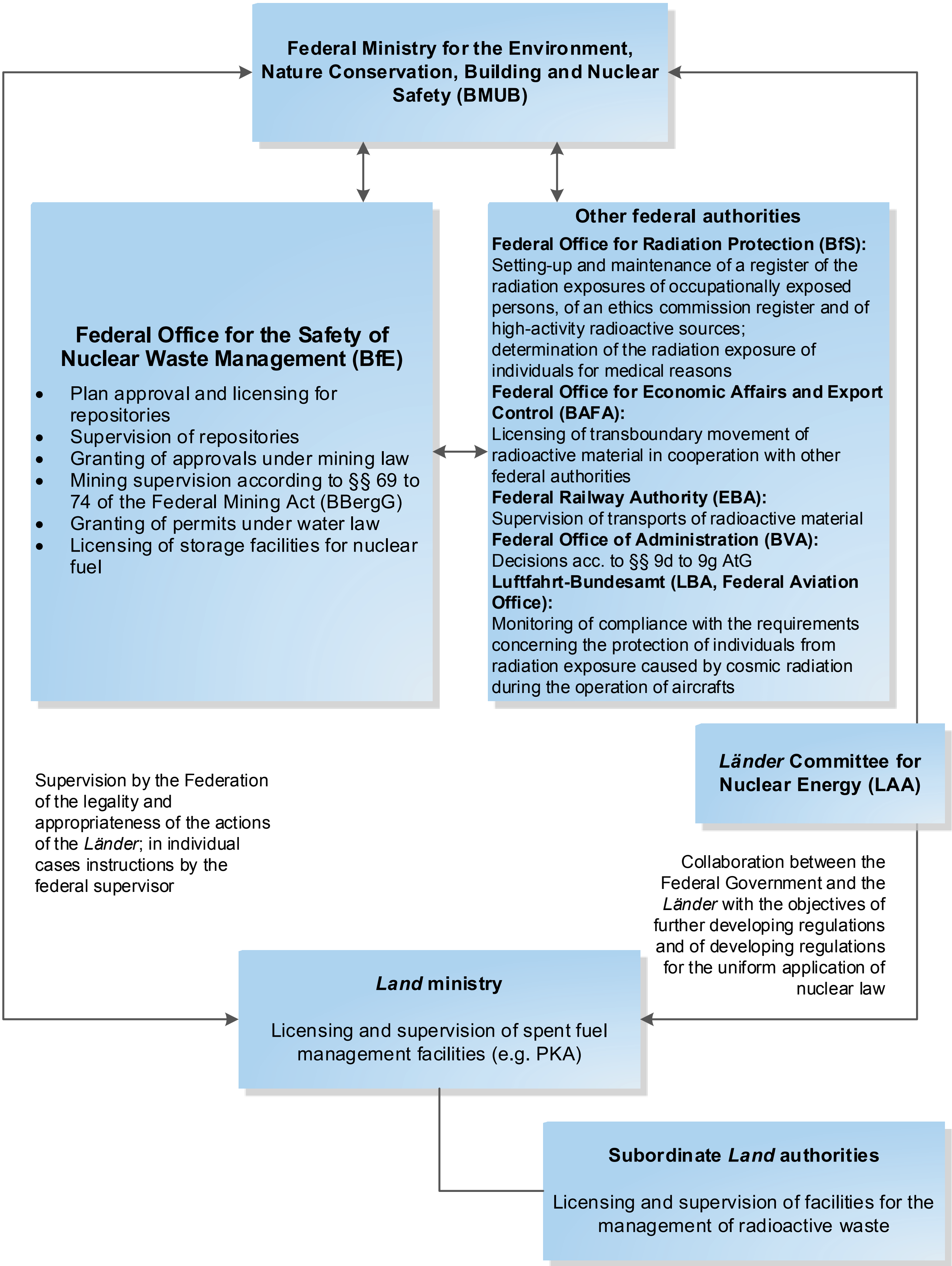
> ***Article 20: Regulatory body***
>
> *(1) Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 19, and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.*
>
> *(2) Each Contracting Party, in accordance with its legislative and regulatory framework, shall take the appropriate steps to ensure the effective independence of the regulatory functions from other functions where organisations are involved in both spent fuel or radioactive waste management and in their regulation.*

E.3.1 Regulatory body

Responsibilities and powers

In the Federal Republic of Germany as a federal state, the “regulatory body” in terms of Article 20 consists of authorities of the Federation and the *Länder* (see Figure E-5).

Figure E-5: Organisation of the “regulatory body”



By organisational decree, the Federal Government specifies the federal ministry competent for nuclear safety and radiation protection. In 1986, this competence was assigned to the then newly founded Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). Previously, the Federal Ministry of the Interior (BMI) had been competent for environmental protection as well as for nuclear law. The responsibility for the organisation, staffing and financing of the Federation's nuclear regulatory authority thus lies with today's Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). The BMUB has the organisational powers and applies for the requisite human and financial resources from the annual federal budget.

Regarding the obligations under the Joint Convention, the BMUB has the responsibility to ensure, both towards the interior of Germany and towards the international community that those in charge of the applicants and operators, federal and *Land* authorities, as well as the authorised experts guarantee at any time and in a sustainable manner the effective protection of man and the environment against the hazards of nuclear energy and the harmful effects of ionising radiation.

The basic regulations on the determination of official responsibilities are contained in the Atomic Energy Act (AtG) [1A-3] in §§ 22 to 24, where the regulatory bodies are listed that are responsible for the implementation of and compliance with the provisions of this Act and statutory ordinances issued hereunder:

- According to § 22 AtG, the Federal Office for Economics and Export Control (BAFA) shall be responsible for licences/approvals involving transboundary movement of radioactive material and withdrawal or revocation thereof, while supervision shall be the responsibility of the Federal Ministry of Finance or customs offices designated by it.
- According to § 23 AtG, the Federal Office for Radiation Protection (BfS) is responsible for, among other things,
  - "the setting-up and maintenance of a register of the radiation exposures of occupationally exposed persons,
  - the setting-up and maintenance of an ethics commission register as defined in § 12(1)(3a), first sentence, its registration and the revocation thereof,
  - the determination, preparation and publication of diagnostic reference values, determination of the radiation exposure of individuals for medical reasons, and the related surveys required in this respect on the basis of an ordinance pursuant to § 12(1)(3b), first sentence,
  - the setting up and maintenance of a register of high-activity radioactive sources according to § 12d."
- According to § 23a AtG, the Federal Office of Administration (BVA) shall be responsible for decisions pursuant to §§ 9d to 9g AtG. This applies, in particular, to expropriations for the purpose of construction and operation of disposal facilities and the associated compensation, as well as to the determination of preservation orders to ensure planning security for disposal facilities or to secure or continue a site investigation for disposal facilities. A preservation order is intended to prevent changes leading to a significant increase in the value of the potential site for a disposal facility or changes which substantially impede the project. It shall be valid for a period not exceeding ten years and may be extended twice by a maximum of ten years.

- According to § 23b AtG, the Federal Aviation Office (LBA) shall be responsible for monitoring compliance with the requirements concerning the protection of individuals from radiation exposure caused by cosmic radiation during the operation of civil aircrafts.
- According to § 23d AtG, the Federal Office for the Safety of Nuclear Waste Management (BfE) is responsible for, among other things,
  - plan approval and licensing according to § 9b AtG and their withdrawal,
  - the supervision of facilities of the Federation pursuant to § 9a(3) AtG, first sentence and of the Asse II mine pursuant to § 19(5) AtG,
  - the granting of approvals under mining law and other permits and licences under mining law required during approval procedures pursuant to § 9b AtG for the construction, operation and decommissioning of federal facilities for the safekeeping and disposal pursuant to § 9a(3) AtG after consultation of the competent mining authority of the respective *Land*,
  - the mining supervision pursuant to §§ 69 to 74 of the Federal Mining Act (BBergG) [1B-15] regarding federal facilities for the safekeeping and disposal pursuant to § 9a(3),
  - the granting of permits or authorisations under water law during approval procedures pursuant to § 9b AtG for federal facilities for the safekeeping and disposal pursuant to § 9a(3) AtG after consultation of the competent water authority,
  - the granting of licences for the transport of nuclear fuel and large sources as well as their withdrawal or revocation, and
  - the granting of licences for the storage of nuclear fuel outside of the government custody as well as their withdrawal or revocation; insofar as these licences are not preparation or part of a licensable activity pursuant to § 7 or § 9 AtG.
- § 24 AtG regulates the responsibilities of the *Land* authorities (excerpt):

  (1) All other administrative functions under Chapter 2 (of the AtG) and the statutory ordinances issued thereunder shall be discharged by the *Länder* on behalf of the Federation. The Federal Railway Authority (EBA) shall be responsible for the supervision of the carriage of radioactive material by rail and ship or on maglev train; this shall not apply to the carriage of radioactive material by private railroad companies if the carriage is exclusively effected on rails owned by those companies.

  (2) The supreme *Land* authorities designated by the *Land* governments shall be responsible for the granting of licences pursuant to §§ 7, 7a and 9 AtG and the withdrawal and revocation of such licences. These authorities shall supervise the facilities pursuant to § 7 AtG and the use of nuclear fuel outside such facilities. They may delegate their functions to subordinate authorities on a case-by-case basis. Complaints against orders of these subordinate authorities shall be decided upon by the supreme *Land* authority. To the extent that provisions other than those laid down herein confer supervisory powers to other authorities, such responsibilities shall not be affected.

  (3) In matters relating to the official duties of the Federal Ministry of Defence, the responsibilities outlined in paras. (1) and (2) above will be carried out by said Ministry or the offices appointed by it, in agreement with the federal ministry in charge of nuclear safety and radiation protection.

The respective *Land* government determines the competent supreme *Land* authorities. Thus, the responsibility for the organisation, staffing and financing of these executive authorities lies solely with the *Land* government. In individual cases, subordinate authorities may also be tasked with supervisory functions.

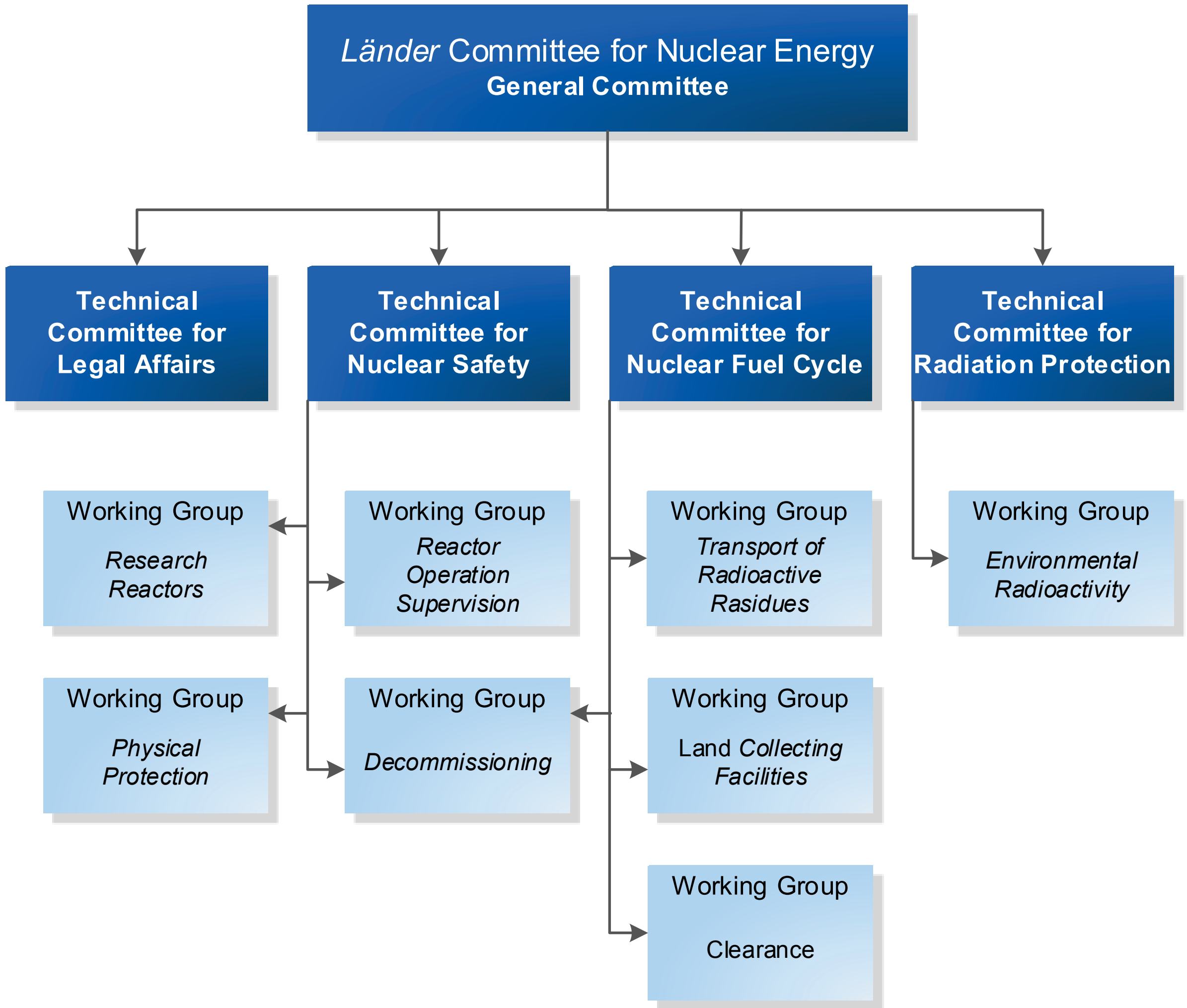
- All operational management tasks related to the planning, construction, operation and decommissioning of facilities for the disposal of radioactive waste will in the future be carried out by the publicly owned company under private law newly founded in accordance with § 9a(3) AtG, i.e. the Bundes-Gesellschaft für Endlagerung mbH (BGE), and bundled there.

Länder Committee for Nuclear Energy (LAA)

The *Länder* Committee for Nuclear Energy (LAA) is a permanent Federation-*Länder* Committee composed of representatives from the nuclear approval and supervisory authorities of the *Länder* and the BMUB. It serves the purpose of preparatory coordination of the activities of federal and *Land* authorities in connection with the enforcement of the nuclear law as well as the preparation of amendments and the further development of legal and administrative provisions as well as of the non-mandatory guidance instruments.

In the interest of nuclear law enforcement as uniform as possible throughout Germany, the competent nuclear approval and supervisory authorities of the *Länder* and the BMUB develop technical rules and procedures for the uniform application of nuclear law by consensus wherever possible, which are then prepared as regulations and promulgated by the BMUB. The BMUB chairs the LAA and also manages its affairs. The Committee's decisions are usually made by mutual consent.

Figure E-6: *Länder* Committee for Nuclear Energy



For preparing decisions to be taken by the General Committee, the LAA (see Figure E-6) avails itself of several Technical Committees on the issues of “Legal Affairs”, “Nuclear Safety”, “Radiation Protection” and “Nuclear Fuel Cycle”, as well as of the Working Groups assigned to these Technical Committees for special permanent tasks. If need be, the Technical Committees may set up ad hoc Working Groups for special and above all urgent individual issues. The Technical Committees and the permanent Working Groups convene at least twice a year and more frequently if necessary. The General Committee convenes at least once a year.

In the area of legislation, the LAA is an important instrument of early and comprehensive involvement of the *Länder* which supplements the formal right of participation of the *Länder* in the legislative procedure of the *Bundesrat*.

Personnel

All regulatory bodies are obliged to give an account of their human resources by drawing up job plans. The costs depend on the extent of the activities; i.e. different numbers of staff are employed in the various *Länder* depending on the number of nuclear facilities to be supervised there. The required funds are established by the *Land* parliaments and the *Bundestag* in their respective budgets.

Nuclear authority of the Federation and authorised experts of the Federation

The nuclear authority of the Federation is a technical department of the BMUB – the Directorate-General Reactor Safety (RS). It comprises three directorates (Safety of Nuclear Installations, Radiological Protection, Nuclear Fuel Cycle). The unit of Directorate-General RS dealing with the fulfilment of the obligations under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management is Directorate RS III (Nuclear Fuel Cycle). As at 1 January 2017, Directorate RS III and its five divisions have 36 staff members.

As an authority subordinate to the BMUB, the BfE carries out administrative tasks of the Federation in the field of licensing of federal facilities for the safekeeping and disposal of radioactive waste conferred on it by the AtG [1A-3], the Repository Site Selection Act (StandAG) [1A-7a] or pursuant to these Acts. The BfE supports the BMUB by providing technical and scientific advice in these fields and moreover, if no other jurisdiction is stipulated by law, performs duties of the Federation in these fields with whose fulfilment it will be commissioned by the BMUB or, with its consent, by the competent supreme federal authority. Moreover, the BfE performs federal enforcement tasks under the AtG, performs tasks in the areas of nuclear safety, transport of radioactive material and the management of radioactive waste prior to disposal. The BfE provides technical support to the BMUB in its responsibility through scientific research.

The Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH is a scientific and technical expert organisation of the Federation. GRS conducts scientific research in the field of nuclear safety and radiation protection, mainly on behalf of the Federation, including radioactive waste management and disposal, and supports the BMUB in technical issues. The Radiation and Environmental Protection Division with its departments Nuclear Fuel, Radiation Protection and Disposal has about 40 experts dealing with radioactive waste management issues.

Nuclear authorities of the *Länder* and authorised experts of the *Länder*

In the 16 *Länder*, there are about 120 staff members working on issues related to radioactive waste management. Another 150 staff members support the nuclear authorities of the *Länder* either at subordinate authorities or as authorised experts. The personnel strength of the different *Länder* varies according to the concrete tasks: e.g., *Länder* with larger nuclear facilities have a larger licensing and supervisory authority than those with no or only very small nuclear facilities.

Advisory commissions and authorised experts

The Reactor Safety Commission (RSK) was founded in 1958 and advises the BMUB on issues relating to nuclear safety and physical protection of nuclear facilities. In addition, it substantially contributes to the advancement of the safety level in nuclear facilities. At present, the RSK consists of 17 members, who are appointed for a period of three years. The statements and recommendations of the RSK are published on the Internet (www.rskonline.de/en).

The Commission on Radiological Protection (SSK), founded in 1974, currently has 20 members. It gives recommendations to the BMUB on all issues related to the protection of the population as well as employees in medical facilities, research, industry and nuclear facilities against ionising and non-ionising radiation. The statements and recommendations of the SSK are published on the Internet (www.ssk.de/en). Further, in the event of a nuclear or radiological incident or corresponding exercises, the SSK will set up the SSK Crisis Management Group.

In 2008, the Nuclear Waste Management Commission (ESK) was founded due to the increasing importance of issues related to nuclear waste management. It currently has 13 members and has taken over the tasks until then performed by the RSK Committee on Fuel Supply and Waste Management. With the ESK, an advisory body has been established which, with its way of working, takes into account the increasing importance of nuclear waste management issues and brings together a broad spectrum of technical expertise. International experiences and approaches are to be included in the Commission's work, a reason why besides experts from Germany, experts from France and Switzerland are also members of the Commission. The experts advise the BMUB in all matters of nuclear waste management. This comprises the aspects of conditioning, storage and transport of radioactive materials and waste, further the decommissioning and dismantling of nuclear facilities as well as disposal in deep geological formations. As a result of its consultations, the Commission reaches resolutions on scientific and technical recommendations or statements directed to the BMUB which are published on the website of the Commission (www.entsorgungskommission.de/en).

For dealing with various focal points in greater depth, the commissions set up committees and working groups, where additional experts may also be involved. The members of the commissions represent a broad spectrum of positions taken and views held according to the state of the art in science and technology. They are independent and not bound by any directives. The BMUB appoints the members of the Commission for a period of up to three calendar years. In general, reappointments in direct succession are possible but should be limited to total tenures of office of no more than six years.

Financial resources of the regulatory body

The financial means available to the authorities for their own personnel and for the consultation of experts are fixed by the German *Bundestag* in the respective budgets.

The BMUB provides around 36 million euros annually for investigations in the fields of reactor safety, radiation protection and on issues related to the nuclear fuel cycle. These funds are used to finance the activities of the advisory committees (RSK, SSK and ESK), the BMUB's direct support, scientific and technical support and the involvement of external experts in international cooperation. Furthermore, projects are financed from these funds that also serve to maintain GRS's competence as expert organisation of the Federation in these fields.

The Federal Ministry for Economic Affairs and Energy (BMWi) has a so-called title of around 36 million euros annually that is to be allocated to project funding related to nuclear safety research (in the fields of reactor safety and radioactive waste management and disposal). Two thirds of this title is allocated to reactor safety research in the framework of which about 100 research projects are carried out. In the area of project funding aimed at site-independent application-oriented basic research in the fields of radioactive waste management/disposal, about 70 projects are carried out in parallel with one third of the title. This includes specific research and development prior to disposal (i.a. on activities relating to storage and waste management), measures of disposal in all host rocks (i.a. on disposal concept development, long-term safety and operational safety), measures during the post-closure phase on sealing systems and monitoring as well as on socio-technical issues.

The Federal Institute for Geosciences and Natural Resources (BGR), an authority subordinate to the BMWi, is charged with geoscientific issues relating to German projects in the field of disposal and also participates in work on research in the field of disposal. The institutional funding of the BGR comes from the budget of the BMWi, but special tasks in the field of disposal are refinanced by the waste producers according to the AtG, the Repository Prepayment Ordinance (EndlagerVlV) and, since 27 July 2013, through cost allocations to the waste producers according to the StandAG [1A-7a].

To cover the necessary expenses for federal facilities, the BMUB collects advance payments for cost-covering contributions to be paid in accordance with § 21b AtG according to the EndlagerVlV [1A-13] from the future users of a facility for disposal. The determination of the contributions to be paid is based on the eligible expenses for the repository projects. The site selection procedure is financed through cost allocations to the waste producers according to §§ 28 et seq. StandAG [1A-7a].

For the decision on approval applications, costs will be charged to the applicant by the competent authorities (federal and *Land* authorities), which cover the expenses of the authorities and the costs for the consultation of authorised experts (§ 21 AtG [1A-3]). The same applies to measures of the supervisory authorities.

Bundes-Gesellschaft für Endlagerung mbH (BGE)

With the entry into force of the Act on the Reorganisation of the Organisational Structure in the Field of Disposal [1A-30], the separation between operators and the administrative aides ended and the operational management tasks are merged into a federally-owned company in private legal form, the BGE.

All tasks related to the planning, construction, operation and closure of disposal facilities as well as of the Asse mine, previously carried out by the BfS as the operator and Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH (DBE) and the Asse-GmbH as administrative aides, will in the future be carried out by the BGE. The transfer of tasks from the BfS to the BGE took place with effect from 25 April 2017. On 15 May 2017, DBE was sold to the Federation. The BGE also assumes the tasks of the project implementer according to the StandAG. To a certain extent, the BGE is given jurisdictional powers if required pursuant to § 9a(3) AtG, third sentence, by way of entrustment of sovereign tasks, which concerns in particular the product control of radioactive waste. However, the BGE is not a public body within the meaning of the Joint Convention.

At the latest by 1 January 2018, the current administrative aides are to be merged with the BGE.

The personnel requirements of the BGE are covered by the transfer of already existing resources of the BfS, the Asse-GmbH and the DBE. Existing professional qualifications, experiences and competencies of the staff can thus be used in the newly established BGE across projects. By using synergies, additional staffing can generally be avoided.

The structural change in the area of disposal is intended to achieve a clearer implementation of the principle of separation according to Article 6(2) of Council Directive 2011/70/EURATOM also with regard to the operators, in particular by assigning the monitoring function for this area to the BfE.

E.3.2 Effective independence of the regulatory functions

The economic use of nuclear energy lies in private hands and not in the public sector, whereas nuclear licensing and supervision are functions of the State. Thus, there is a separation of spheres of interest.

The only instance where a conflict of interests might be conceivable at all is in situations where financial promotion or the subsidising of scientific research occurs in the same government sector such as nuclear licensing and supervision of the respective nuclear facilities. However, at the federal level, there is no such risk of a conflict of interests since functions are assigned to different departments. Licensing and supervision of nuclear facilities generally lies within the responsibility of the *Länder*; legality and appropriateness supervision is performed by the Federal Ministry for the Environment, Nature Conservation, Construction and Reactor Safety (BMUB). In the area of economic interests of the nuclear energy industry in Germany, project funding of reactor safety research and site-independent research on radioactive waste management/disposal, the Federation will only take actions through the BMWi.

The regulatory organisation in Germany thus fulfils the requirements of Article 20(2) of the Joint Convention.

This also applies to the organisation of the planning, construction, operation and closure of facilities for the disposal of radioactive waste. According to § 9a(3) AtG [1A-3], this is a federal task assigned by the Federation to the federally-owned private-law company BGE. The BGE is subject to nuclear supervision by the BfE.

The BfE also supervises the implementation of the site selection procedure for a repository according to § 19(1) to (4) AtG. The procedure for the approval of a facility for the disposal of radioactive waste is principally carried out as a plan approval procedure (see Chapter E.2.3 for details). In the cases where the site is determined by federal law, a licence shall substitute the plan approval. The BfE is also responsible for the planning and approval of disposal facilities. In this case, the BGE will be acting as the applicant.

The monitoring of compliance with the requirements under nuclear and radiation protection law and the stipulations in the approvals takes place within the BfE.

The BMUB is responsible for supervising the execution of tasks by the BfE in terms of legality and appropriateness as well as the shareholding management for the BGE.

F Other general safety provisions

This section deals with the obligations under Articles 21 to 26 of the Convention.

> **Developments since the Fifth Review Meeting:**
>
> The Commission to Review the Financing for the Phase-out of Nuclear Energy (KFK), established by the Federal Cabinet, has drawn up recommendations on the financing of decommissioning, dismantling and radioactive waste management, which were documented in a final report [KFK 16]. The recommendations form the basis for the Act on the Reorganisation of Responsibility in Nuclear Waste Management [1A-31], which entered into force on 16 June 2017 after state aid approval by the European Commission.

F.1 Article 21: Responsibility of the licence holder

> ***Article 21: Responsibility of the licence holder***
>
> *(1) Each Contracting Party shall ensure that prime responsibility for the safety of spent fuel or radioactive waste management rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.*
>
> *(2) If there is no such licence holder or other responsible party, the responsibility rests with the Contracting Party which has jurisdiction over the spent fuel or over the radioactive waste.*

F.1.1 Responsibility of the licence holder

The licence holder has primary responsibility for the safety of a spent fuel management facility or a radioactive waste management facility. He may only be issued with a licence if he meets all the legal prerequisites for licensing. In the case of storage of spent fuel licensed under § 6 of the Atomic Energy Act (AtG) [1A-3] or facilities licensed under § 7 AtG (e.g. conditioning facilities for spent fuel), one such prerequisite is the trustworthiness and technical qualification of the responsible individuals. Certified proof of this prerequisite and its acknowledgement by the authorities provide the basis for responsible performance under the licence.

In the case of companies with a number of authorised board members to represent it, the licence holder has to nominate to the competent authority the individual from the circle of authorised board members who assumes the role of radiation protection supervisor. This same person is also responsible for ensuring a functioning organisational structure and the deployment of qualified personnel at the facility.

The holder of a licence issued according to § 31(1) of the Radiation Protection Ordinance (StrlSchV) [1A-8] is responsible for the entire field of radiation protection. In addition, § 31(2) StrlSchV stipulates that he has to appoint a sufficient number of radiation protection officers for technical activities and monitoring of operation. Together with the radiation protection supervisor, these ensure due compliance with all protection and supervisory provisions of the StrlSchV (see reporting on Article 24 of the Convention). According to § 32(5) StrlSchV, the radiation protection officers must not be hindered in the performance of their duties or suffer any disadvantages by virtue of their activities.

In order to better meet the specific requirements of nuclear safety at facilities licensed under § 7(1) AtG or activities licensed under § 6 AtG, the additional position of nuclear safety officer has been created as part of the organisational structure of the plant [1A-17]. It is his responsibility to supervise nuclear safety issues in all areas of operation and in doing so must act independently of the corporate interests of cost-effective plant operation. He should be involved in all activities concerning modifications, should assess any reportable events and the evaluation of operating data, and has the right to report directly and at any time to the plant manager.

When performing their tasks, the radiation protection officers, together with the nuclear safety officer, act independently from the company hierarchy.

Any enforcement measures on the part of the competent authorities will always be directed in the first instance at the holder of the licence, with the objective that the ultimately responsible individuals will personally meet their respective obligations. If this is not the case, the authority can question the trustworthiness of such individuals, which is a prerequisite for granting the licence. Consequently, in such cases, any proceedings relating to an administrative or criminal offence will be directed at individual persons (see reporting on Article 19(2)(v) in Chapter E.2.6).

F.1.2 Responsibility if there is no licence holder

If radioactive substances are lost, found or misused, the *Land* concerned is likewise responsible for averting nuclear-specific danger. In severe cases, it is supported in this task by the Federal Office for Radiation Protection (BfS). This applies, in particular, to the finding of radioactive substances for which no other responsible party can be identified.

If there is no licence holder or other party responsible for management or storage facilities for radioactive waste, or such a person fails to meet his obligations, then responsibility for the safety of the facility or related activities shall rest with the competent *Land*.

In cases where the direct owner of nuclear fuels has no authorisation for possession, he shall establish authorised possession pursuant to § 5(2) AtG. If such authorised possession cannot be established, the Federal Office for the Safety of Nuclear Waste Management (BfE) shall temporarily take the nuclear fuels into its charge ("government custody") according to § 5(3) AtG [1A-3]. Such a situation may also arise if nuclear fuels are found or in case of loss of authorisation on the part of the private licence holder (e.g. in case of insolvency of the former owner or revocation of the licence). If, however, the supervisory authority issued any other order under § 19(3) AtG, then this order shall have priority over government custody. Whoever is responsible for nuclear fuels under government custody shall also ensure authorised possession outside government custody (§ 5(3)(2) AtG). This does not only apply to the direct owner who delivered to the authority responsible for custody but also to the owners of utilisation and consumption rights to nuclear fuel held in government custody, and to anyone who is required to take over or take back nuclear fuel from a third party (§ 5(3)(3) AtG).

According to § 23d(8) AtG, the BfE is responsible for the execution of government custody. The BfE may cause the private licences to (re-)assume their responsibility with regard to the handling of nuclear fuels by issuing orders stipulating that nuclear fuels under government custody are to be returned to the charge of the private owners. This indicates that government custody of nuclear fuels is an exceptional case in the handling of these materials.

F.2 Article 22: Human and financial resources

> ***Article 22: Human and financial resources***
>
> *Each Contracting Party shall take the appropriate steps to ensure that*
>
> *i) qualified staff is available as needed for safety-related activities during the operating lifetime of a spent fuel and a radioactive waste management facility;*
>
> *ii) adequate financial resources are available to support the safety of facilities for spent fuel and radioactive waste management during their operating lifetime and for decommissioning;*
>
> *iii) financial provision is made which will enable the appropriate institutional controls and monitoring arrangements to be continued for the period deemed necessary following the closure of a disposal facility.*

F.2.1 Human resources

The safe operation of nuclear facilities, including spent fuel and radioactive waste management facilities, requires a high degree of competence of all those involved, i.e. operators, manufacturers, research institutions, authorities and authorised experts. For safe operation of nuclear facilities, the operators are responsible for providing the necessary competence.

According to § 7(2)(1) and (2) of the Atomic Energy Act (AtG) [1A-3], a licence for the construction or operation of a facility may only be granted if

- there are no known facts which could cast doubt on the reliability of the applicant and of the persons responsible for the construction and management of the facility and the supervision of its operation; and the persons responsible for the construction and management of the facility and the supervision of its operation have the required technical qualifications,
- measures have been taken to ensure that the persons otherwise engaged in operation of the facility have the necessary expert knowledge concerning the safe operation of the facility, the potential hazards, and the protective measures to be taken.

Similar requirements as regards the reliability of the applicant can also be found in § 6(2)(1) AtG on the licensing for the storage of nuclear fuel as well as in § 9(2)(1) and (2) AtG on the treatment, processing and other utilisation of nuclear fuel outside facilities requiring a licence according to § 7 AtG.

§ 30 of the Radiation Protection Ordinance (StrlSchV) [1A-8] includes regulations concerning the requisite qualification and knowledge in the field of radiation protection as well as its acquisition and conservation.

The Ordinance on the Nuclear Safety Officer and the Reporting of Incidents and other Events (AtSMV) [1A-17] regulates the appointment of nuclear safety officers for nuclear facilities or activities licensed under § 7(1) AtG and § 6 AtG, respectively.

The legal bases are further specified within the framework of guidelines. This is realised in particular by guidelines on the required technical qualification of the responsible personnel and on the assurance of the necessary knowledge of the persons otherwise engaged in nuclear power plants, which are applied accordingly. Furthermore, the exchange of information and knowledge, including experience feedback, is regulated in special requirements.

In addition, there is the Guideline on technical qualification in radiation protection [3-40] which specifies the extent and required proof of the technical qualification of radiation protection supervisors and radiation protection officers.

The implementation of the content of these regulations results in a hierarchy of responsibilities, each of which has varying requirements with respect to technical qualification and expert knowledge.

Prior to the deployment of personnel stated in guideline [3-2] relating to the proof of the technical qualification of nuclear power plant personnel (management personnel), the supervisory authority requires the submission of documents which verify the necessary technical qualification and practical experience. It reviews these documents for compliance with the requirements of the guideline.

In addition to vocational training, there are appropriate training opportunities in Germany at universities and technical colleges, for example in the field of nuclear and reactor technology at the universities of Aachen, Clausthal-Zellerfeld, Dresden, Essen, Karlsruhe, Munich, Stuttgart and Zittau.

Recognised courses are also provided in the non-governmental sector, e.g. at the various Chambers of Industry and Commerce and at the Haus der Technik e.V. in Essen.

In order to ensure a sufficient number of qualified/well-educated staff for safety related work, existing knowledge must also be revised and updated.

- In relation to individuals, this is ensured by the regulations on recurring training in the field of radiation protection. Instruction courses are to be held every year according to the Guideline relating to the assurance of the necessary knowledge of other personse in the operation of nuclear power plants [3-27]. For the other groups, instructions should be given at least every two or three years, respectively.

- Moreover, research institutions in the field of reactor safety joined to found the Alliance for Competence in Nuclear Technology (Kompetenzverbund Kerntechnik – KVKT) of German research institutes in March 2000 in order to maintain an adequate level of know-how in the nuclear and radiation protection sector. It consists of the permanent members the Helmholtz-Zentrum Dresden-Rossendorf (HZDR), the Forschungszentrum Jülich GmbH (FZJ), the Karlsruhe Institute of Technology (KIT) and the Gesellschaft für Anlagen- und Reaktorsicherheit gGmbH (GRS) together with their partner universities and the Materials Testing Institute University of Stuttgart (MPA). In addition, the KVKT contributes to the close cooperation with the universities and the industry, as well as the cooperative support of international initiatives on maintaining competence in the field of nuclear energy.

- The Competence Network for Radiation Research (Kompetenzverbund Strahlenforschung – KVSF) was established in 2007 and, as a forum of excellence, should highlight the scientific and the social and political importance of radiation research. Active public relation of the KVSF shall contribute to strengthen the position of radiation research and its public perception. One of the KVSF's primary concerns is to initiate a systematic and continuous promotion of young researchers in the field of radiation research in order to ensure the scientific level in the long-term and to cover our future need for qualified experts. Six experts from large research institutions like e.g. the German Cancer Research Center (DKFZ), FZJ, HZDR, the Helmholtz Zentrum München (HMGU) as well as KIT are appointed to the KVSF. Six further experts from different fields of radiation research are proposed by the German Society of Medical Physics (Deutsche Gesellschaft für Medizinische Physik – DGMP), Fachverband für Strahlenschutz e.V., Deutsche Gesellschaft für Radioonkologie e.V. (DEGRO), Deutsche Gesellschaft für Epidemiologie e.V. (DGEpi) and Gesellschaft für biologische Strahlenforschung e.V. (GBS). The German Commission on Radiological Protection (SSK), the Federal Office for Radiation Protection (BfS) and the Karlsruhe Project Management Agency (PTKA) appoint one representative each.

- The German association for repository research (Deutsche Arbeitsgemeinschaft Endlagerforschung – DAEF) was established in 2013 and considers itself as an independent association with its focus on the safe disposal of radioactive waste and the continuous further development of the scientific and technical expertise in this field also including socioeconomic issues. An essential object is the further development and intensification of the cooperation of the DAEF members in the field of repository research. In addition, the DAEF offers scientific and technical advice to the Federal Government and its authorised federal and *Land* authorities as well as to the *Bundestag* and other interested institutions. The permanent members of the DAEF are DBE TECHNOLOGY GmbH, the Deutsche Montan Technologie für Rohstoff, Energie, Umwelt e.V. (DMT), FZJ, GRS, HZDR, the Institute of Geomechanics GmbH (IfG), the TÜV Rheinland ISTec GmbH, KIT, the Institute for Applied Ecology Öko-Institut e.V., the Aachen Rhenish-Westphalian University of Technology (RWTH), the Freiberg University of Mining and Technology (TU Bergakademie Freiberg), the Clausthal University of Technology and the University of Stuttgart.

- The power plant operators also have committed themselves to the coordinated promotion of German training and research institutions to contribute to the maintenance of competence and junior staff recruitment in the field of nuclear technology.

- The training and further qualification of expert staff from authorities and authorised expert organisations is the objective of the events offered by the GRS within the framework of its GRS Academy. There are seminars on e.g. the following topics: fundamentals of reactor physics, nuclear fuel supply and waste management, prominent events/incidents/accidents in nuclear facilities, International Nuclear Event Scale (INES) User Manual of the International Atomic Energy Agency (IAEA), fundamentals of radiation protection, radiation emergency preparedness, external hazards, regulatory supervision of the operation of nuclear reactors, legal and technical nuclear standards, selected topical issues of the nuclear licensing and supervisory procedure, fire protection in nuclear power plants, operation management of nuclear power plants, and decommissioning of nuclear facilities.

Competent and motivated personnel will also be needed in future for the tasks to be performed during the phase-out of nuclear energy. The motivation for working in an area with only limited career prospects in Germany can only be maintained if this work is regarded as being important and recognised by society.

F.2.2 Financial resources during operation and decommissioning

As far as nuclear facilities are operated by public operators, the competent body provides the necessary financial resources also for safety-related tasks associated with these facilities. For the public operators, resources are entered in the respective current budget for the decommissioning and dismantling costs, including the necessary qualified staff (see reporting on Article 26, Chapter F.6.2) regarding the commissioning of nuclear facilities.

Under the principle, that the costs incurred for radioactive waste management shall be paid by the waste producers, the nuclear power plant operators are obliged to bear the costs for the decommissioning and dismantling of nuclear power plants and the disposal of the radioactive waste generated by them according to § 9a(1) AtG [1A-3], unless otherwise specified in the Act on the Reorganisation of the Organisational Structure in the Field of Disposal (see below). For nuclear facilities and other waste management facilities (§ 9h AtG) and pursuant to § 7c(2)(2) AtG, the licence holder shall be obliged to schedule and keep ready permanent appropriate financial instruments to fulfil his obligations concerning the nuclear safety of the particular nuclear installation. In order to ensure compliance, § 19 AtG requires government supervision as a regulatory instrument.

Waste management costs will arise over a period of several decades. At the same time, due to the phase-out of nuclear energy, the amount of the radioactive waste is limited and thus more calculable as compared to the periods of open-ended operation. Moreover, the period when the operation of power plants can produce profits for the financial provision for the disposal of radioactive waste is restricted.

Against this background, in October 2015, the Federal Government had set up the Commission to Review the Financing for the Phase-out of Nuclear Energy (KFK). The task of the KFK was to examine how the financing of the decommissioning and dismantling of nuclear power plants and of radioactive waste management can be secured such that the companies are financially capable to meet their obligations in the nuclear field in the long term.

With the – unanimously adopted – final report published on 27 April 2016, the KFK submitted a cross-party and cross-society proposal. Accordingly, the responsibility for storage and disposal shall be in the hands of the state. The financial burden shall be borne by the companies by paying the necessary liquid funds into a fund under public law.

The Act on the Reorganisation of Responsibility in Nuclear Waste Management (act amending various acts) [1A-31], which entered into force on 16 June 2017 after state aid approval by the European Commission, implements the recommendations of the KFK. The aim is to regulate the responsibility such that the financing for decommissioning, dismantling and waste management is secured in the long term without passing on the costs unilaterally to society and without jeopardising the economic situation of the operators (see Chapter E.2.2 for details on the Act on the Reorganisation of Responsibility in Nuclear Waste Management).

Accordingly, in the future, the Federation, to be more precise, the public-law foundation *“Fonds zur Finanzierung der kerntechnischen Entsorgung“* (fund for the financing of nuclear waste management) will be responsible for the implementation and financing of storage and disposal. The funds for storage and disposal were provided to the Federation by the operators and transferred to the fund. The fund collects, deposits and disburses the funds.

The operators of the nuclear power plants had to transfer an obligatory basic amount of around 17.9 billion euros to the fund by 1 July 2017. Against payment of an additional risk premium by 31 December 2022 of around 35 % of the basic amount, the operators can terminate the obligation to make any necessary additional payments into the fund. In addition, under certain legal requirements, there is the possibility of concluding an instalment agreement. Thus, payments into the fund consist of the basic amount of a total of around 17.9 billion euros and the voluntary risk premium amounting to a total of around 6.2 billion euros, i.e. a total amount of around 24 billion euros. This total amount has been paid by the operators into the fund by 1 July 2017.

The operators of the nuclear power plants will continue to be responsible for the entire management and financing in the fields of decommissioning, dismantling and proper packaging of radioactive waste and will thus have to continue to set aside provisions for these fields in accordance with tax and commercial law. The amount of provisions for decommissioning and dismantling set aside by private operators is approx. 17.8 billion euros (as at 31 December 2014).

The Transparency Act, also enacted under the Act on the Reorganisation of Responsibility in Nuclear Waste Management which amends various acts, establishes further requirements for the transparency regarding the provisions for the waste management obligations remaining with the operators and, inter alia, the right of the Federal Office for Economic Affairs and Export Control

(BAFA) to access information. According to the Transparency Act, the operators must present detailed information on the provisions they have made, broken down by the various tasks of radioactive waste management, on the basis of the annual financial statements. This presentation must include a forecast of the expenses expected for each task of radioactive waste management for the coming financial years. Furthermore, the presentation must show what liquid assets the operator will have at the reference date to ensure that the expenses are financially covered. The authority's right to information supports the transparency requirements for the creation of provisions. The intention of the right of information is, on the one hand, to encourage the operators to build up adequate provisions and, on the other hand, to give the Federation and the competent tax offices clarity on the cost estimates used to calculate the amount of provisions needed. There are no plans for changing the applicable accounting provisions of commercial law.

In addition, the Follow-up Liability Act, Article 8 of the Act on the Reorganisation of Responsibility in Nuclear Waste Management, also contains regulations on the follow-up liability of the companies for the obligations of the operators with respect to radioactive waste management. At present, the operators of nuclear power plants are incorporated in groups under company law and, due to profit transfer and management control agreements within the groups, largely in such a financial situation that the groups' assets are liable for the costs of decommissioning, dismantling and waste management. So far, however, there have been no legal regulations that could ensure that this situation will continue to exist. In case of making use of restructuring possibilities by the groups under company law, there was therefore the risk of insolvency of the operating companies. This led to considerable financial risks for the State and society, which are intended to be reduced with the Follow-up Liability Act.

The Follow-up Liability Act introduces a statutory follow-up liability of controlling companies for their controlled operating companies for the costs of decommissioning and dismantling of their nuclear power plants. In addition, the Follow-up Liability Act also regulates a statutory follow-up liability for payment obligations to the public-law fund into which the companies will transfer the funds for storage and disposal.

This liability only applies if the operating company ceases to comply with its payment obligations, for example due to insolvency, or ceases to exist.

F.2.3 Financial resources after closure of a repository

Once a repository will have been sealed, a monitoring phase can be part of the requirements for closure. After release of the repository from nuclear supervision, the remaining surveillance is a governmental task. It is intended to introduce a system for surveillance which can mainly take credit from the passive safety measures that are to be included in the design of the repository. Since surveillance is carried out under government control, funding is provided through the federal budget.

F.3 Article 23: Quality assurance

> ***Article 23: Quality assurance***
>
> *Each Contracting Party shall take the necessary steps to ensure that appropriate quality assurance programmes concerning the safety of spent fuel and radioactive waste management are established and implemented.*

F.3.1 Quality assurance

The concept and design of facilities for the conditioning, storage and disposal of spent fuel and radioactive waste include constructive and administrative measures to protect the general public and workers against hazards arising from the release of radioactive substances and ionising radiation. The effectiveness of these measures is ensured within the framework of a quality assurance programme which also considers ageing phenomena and preventive maintenance. Nuclear safety standard KTA 1401 of the Nuclear Safety Standards Commission specifies general requirements for quality assurance regarding nuclear power plants. The requirements of this safety standard are applied wherever relevant. These include the principles of operational organisation, planning and design, production and construction including quality control, specified normal operation and incidents, documentation and archiving, as well as auditing of the quality assurance system itself. Quality assurance measures are implemented by the operational management system and defined in the licence and the related application documents, in particular in the safety report. The nature and scope of measures to safeguard quality characteristics are oriented towards their significance for preventing damages caused by radiation exposure. In the licensing procedure, plant components are assigned to quality class “nuclear”, which in turn is subdivided according to safety significance as well as special significance in terms of radiation protection or outstanding significance in terms of radiation protection, and to quality class “conventional”. For nuclear plant components, additional design approval documents have to be prepared according to the requirements, while conventional quality requirements according to the state of the art in science and technology and the applicable technical rules and regulations are sufficient for conventional plant components.

The applicant or licence holder is responsible for the planning, performance and control of the effectiveness of quality assurance. In this respect, an essential requirement of safety standard KTA 1401 is the technical knowledge and qualification of the personnel.

The nature and scope of initial inspection and, where necessary, recurrent inspections by the supervisory authority, which also monitors compliance with the measures, are specified within the nuclear licensing procedure. The supervisory authority may consult authorised experts for the inspections. Moreover, it has access to the facility at any time to carry out necessary inspections.

Some quality assurance requirements in international standards, e.g. in DIN EN 45004, are not addressed by safety standard KTA 1401. However, the Atomic Energy Act (AtG) [1A-3] and the Radiation Protection Ordinance (StrlSchV) [1A-8] generally require compliance with the state of the art in science and technology. This ensures that international quality assurance requirements are also taken into account.

F.3.2 Product control

Product control of radioactive waste exists as a part of general quality assurance. Its task is to ensure compliance with waste acceptance requirements. These are the result of the site-specific safety analysis for the repositories. The corresponding evidence requires the existence of organisational and administrative regulations defining the spheres of responsibility, tasks and activities of the parties involved. Within the scope of its responsibility for the operation of a repository, the Bundes-Gesellschaft für Endlagerung mbH (BGE) (third party according to § 9a(3) second half of the second sentence of the AtG) ensures that the waste acceptance requirements are met by examining waste packages and by qualification and accompanying control of conditioning measures. This is a sovereign task.

Product control comprises regulations on quality assurance in the registration and conditioning of radioactive waste and in the production of waste containers, including the registration and documentation of the characteristics of the waste packages relevant for disposal. Organisational and administrative regulations governing the spheres of responsibility, tasks and activities of the parties involved are laid down in the guideline relating to the control of radioactive residues and radioactive waste of 19 November 2008 (see Figure F-1) and the agreements between the BGE and the waste producers. The supervisory authorities of the *Länder*, the BGE, the commissioned experts, the waste producers and the service companies acting on their behalf, as well as the operators of the storage facilities and *Land* collecting facilities are all involved in product control. The nature and extent of product control measures are determined depending on the conditioning technique, waste characteristics and requirements of the repository. The measures required in order to guarantee the safety of a repository for radioactive waste are laid down in the respective plant licence (plan approval decision).

In implementing the recommendations of the Commission to Review the Financing for the Phase-out of Nuclear Energy, the Act on the Reorganisation of Responsibility in Nuclear Waste Management [1A-31] stipulates that the Federation is to transfer the properly packaged waste packages of the nuclear power plant operators into storage, for which it is responsible. The task of the product control is to confirm compliance with the acceptance conditions for the storage and thus also the proof of proper packaging.

The proper packaging for the transfer into storage is aimed at compliance with the Konrad waste acceptance requirements. For reasons of procedural simplification, the Federation intends that with the confirmation of compliance with the prerequisites for transfer into storage, suitability of a package for disposal is confirmed as well. The power plant operators are entitled to receive a provisional certification by the BGE commissioned with product control once the conditions for transfer are met.

Figure F-1: Product control flow chart for waste packages regarding their conditioning, storage and disposal

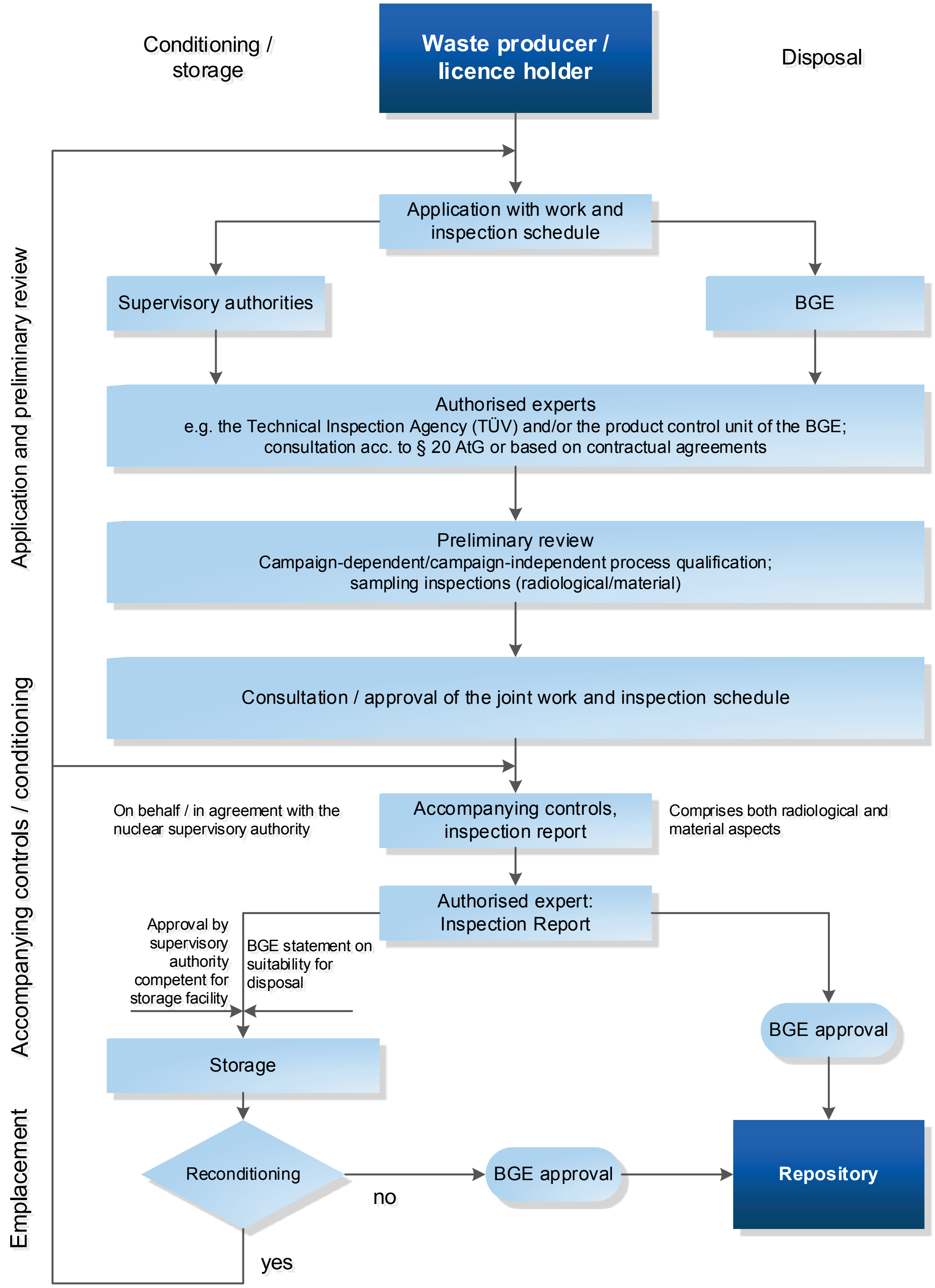


Figure F-2: Wipe test for product control on a MOSAIK container (Copyright: GNS)

Regulations on product control exist for the radioactive waste to be emplaced in the Konrad repository. Only those radioactive wastes may be disposed of in the Konrad repository which demonstrably meet the waste acceptance requirements for disposal.

According to the Konrad waste acceptance requirements (see Chapter D.3.3), these are divided into

- basic requirements for radioactive waste to be disposed of,
- requirements for waste packages,
- requirements for waste products,
- requirements for waste containers,
- activity limitations, and
- mass limitations for non-radioactive harmful substances.

Compliance with these requirements is to be demonstrated as part of the product control by

- design testing of containers including accompanying controls during fabrication,
- process qualification and accompanying control of conditioning measures, and

random checks on waste products/waste packages.

Design testing

As part of the design testing, the containers for disposal are subjected, among other things, to stacking pressure tests, lifting tests, drop tests, thermal tests and, where appropriate, leak tests.

Process qualification

The qualification of conditioning measures is either performed campaign independently determining the relevant operating conditions in a manual or per campaign on the basis of a schedule. Relevant measures with a view to demonstrating compliance with the waste acceptance requirements are, in particular,

- identification of the waste according to type and origin,
- demonstration of compliance with the basic requirements for waste products as well as other requirements to be fulfilled for the specific waste product groups,
- qualified determination of the radionuclide-specific activity inventory,
- determination of the mass of waste products and containers, the waste package mass and the gravity position, and
- determination of dose rate and contamination.

The identification of the waste and determination of the masses do not only meet radiological requirements but also provide significant evidence on the material composition in order to comply with the mass limits for non-radioactive harmful substances.

The procedure described in the schedule is assessed separately for individual raw waste campaigns with regard to its suitability for the production of waste packages meeting the requirements for disposal. The approval of the procedure by the BGE takes place with accompanying controls with regard to the demonstration of compliance with the waste acceptance requirements.

Random sampling

Waste packages from non-qualified procedures are controlled by the BGE after production for compliance with the waste acceptance requirements. Type and scope of control measures depend on the extent to which the documentation submitted demonstrates compliance with the waste acceptance requirements.

F.4 Article 24: Operational radiation protection

Article 24: Operational radiation protection

(1) Each Contracting Party shall take the appropriate steps to ensure that during the operating lifetime of a spent fuel or radioactive waste management facility

i) the radiation exposure of the workers and the public caused by the facility shall be kept as low as reasonably achievable, economic and social factors being taken into account;

ii) no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection;

iii) measures are taken to prevent unplanned and uncontrolled releases of radioactive materials into the environment.

(2) Each Contracting Party shall take appropriate steps to ensure that discharges shall be limited

i) to keep exposure to radiation as low as reasonably achievable, economic and social factors being taken into account; and

ii) so that no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection.

(3) Each Contracting Party shall take appropriate steps to ensure that during the operating lifetime of a regulated nuclear facility, in the event that an unplanned or uncontrolled release of radioactive materials into the environment occurs, appropriate corrective measures are implemented to control the release and mitigate its effects.

F.4.1 Basis

The German radiation protection law is currently undergoing a fundamental revision and update phase. Council Directive 2013/59/EURATOM of 5 December 2013 [1F-24] is to be transposed into national law by February 2018. This is done by means of an act to reorganise the protection against the harmful effects of ionising radiation (Radiation Protection Act – StrlSchG) [1A-29b] and additional ordinances. In the Radiation Protection Act, a clear distinction is drawn between planned, existing and emergency exposure situations. The new radiation protection law will not be fully in force on the date of reference of this report. Regulations on emergency exposure situation (see Chapter F.4.3), which also relate to the protection of the emergency workers, will already enter into force in 2017. The well-established regulations on planned exposure situations are being updated and expanded to include workplaces with naturally occurring radioactivity material (NORM). With regard to radiation protection in the facilities, the position of the radiation protection officer will be significantly strengthened, the dose limit for the lens of the eye from occupational exposure will be reduced to 20 mSv per calendar year and the additional national organ dose limits for internal organs will cease to apply. Furthermore, the international exchange of data concerning the exposure data will be simplified, the exemption levels of specific activity will be harmonised with the values for unrestricted clearance and the activity values for classification as high level radioactive sources are set to the D-values of the International Atomic Energy Agency (IAEA). The dose limit for the population will in future refer to the sum of all radiation exposures from practices requiring a licence or notification pursuant to the StrlSchG or the Atomic Energy Act (AtG), from government custody of nuclear fuel, from construction, operation and closure of federal facilities for radioactive waste disposal requiring plan approval, and from the prospection, extraction or treatment of radioactive mineral sources, if this is subject to the operating plan requirements according to § 51 of the Federal Mining Act (BBergG).

As the Radiation Protection Act will not yet be in force on the reference date of this report, the current radiation protection law is referred to below.

The legal basis for radiation protection in the nuclear facilities mentioned above is currently the Radiation Protection Ordinance (StrlSchV) [1A-8]. The Radiation Protection Ordinance is subordinate to the AtG [1A-3], which outlines the fundamental requirements to be observed in the construction and operation of nuclear facilities and the handling of radioactive materials.

The basic safety standards on radiation protection of the IAEA [IAEA 14a] and the recommendations of the International Commission on Radiological Protection (ICRP) are taken into account. The ALARA principle is taken into account by § 6 StrlSchV which forbids any unnecessary radiation exposures and contamination of man and the environment and which contains an obligation, in terms of the practices relevant here, to keep the contamination of man and the environment as low as possible, even below the limits, by taking into account the state of the art in science and technology and consideration of all circumstances of the individual case.

F.4.2 Radiation exposure of occupationally exposed persons

Occupationally exposed persons refers to persons who could receive an effective dose of more than 1 mSv, an organ dose for the lens of the eye of more than 15 mSv or an organ dose for the skin of more than 50 mSv from practices per calendar year. In § 54 StrlSchV, a distinction is drawn between two categories of occupationally exposed persons, i.e. between Category A and Category B. This categorisation is made for the purpose of defining the corresponding necessary control and preventive occupational medical care. For persons of Category B, the effective dose may exceed 1 mSv per calendar year, for individuals of Category A it may exceed 6 mSv. For assignment to these categories, different organ dose thresholds are defined. Persons exposed to radiation by virtue of their occupation are monitored for their radiation exposure by means of official and company dosimeters. According to § 55 StrlSchV, they must not receive an effective dose of more than 20 mSv per calendar year. Limits are also specified for individual organ doses. Further details can be found in Table F-1.

Exceptions to these limits apply to persons under the age of 18, for whom the effective dose limit is only 1 mSv/a (instead of 20 mSv/a). In individual cases, the authority may permit effective doses of up to 6 mSv/a for apprentices and students between the age of 16 and 18 if this is necessary for them to achieve the objectives of their professional training.

Furthermore, women of child-bearing age must not receive a cumulative dose of more than 2 mSv per month to the uterus. For an unborn child whose mother may continue working as occupationally exposed person after her pregnancy has become known, the limit is 1 mSv for the time from the notification of the pregnancy until its end if an incorporation of radioactive materials can be excluded. In these cases, the uterus dose is to be determined per working week. The dose limit refers to the sum of external and internal radiation exposure.

According to § 56 StrlSchV, the maximum effective dose permitted over an individual’s entire working life is 400 mSv.

According to § 58 StrlSchV, the aforementioned dose limits may only be exceeded in specially permitted cases.

In addition, there are regulations for emergency workers in emergency exposure situations and other emergency situation, for example for the protection of life or health or for the preventing or combating a disaster (see Chapter F.5.1 for details on the protection of workers and Table F-1).

With the limits cited, the requirements according to the basic safety standards on radiation protection of the IAEA [IAEA 14a] were partially fulfilled in Germany and partially, more restrictive provisions were stipulated.

For the documentation of radiation exposure, records are kept for occupationally exposed persons (medical records) listing both the results of the official dosimeters and those of any other dosimeters kept for operational reasons, or of dose calculations. The results of the official dosimetry are additionally registered centrally at the radiation protection registry of the Federal Office for Radiation Protection (BfS). Specifications are laid down in § 12c of the Atomic Energy Act (AtG) and § 112 StrlSchV. Occupationally exposed persons are subject to medical supervision, which for persons of Category A consists at least of one examination to be repeated annually.

In keeping with the requirements of the StrlSchV, the protection of occupationally exposed persons from internal and external radiation exposure is already taken into account in the planning of the nuclear facility, and must be ensured during its operation by appropriate protective measures and protective clothing, especially when handling unsealed radioactive material. According to § 43(1) StrlSchV, the protection of occupationally exposed persons from external and internal radiation exposure shall be effected as a matter of priority by means of structural and technical devices or by means of suitable procedures. According to § 43(2) StrlSchV, the working conditions for pregnant women must be organised in such a way that internal occupational radiation exposure is excluded. For work to be carried out in the controlled area, radiation protection instructions are drawn up as part of the preparation of the work, specifying the actions to be taken.

According to § 6 StrlSchV [1A-8], the operators of nuclear facilities are legally obliged to avoid any unnecessary radiation exposure and contamination of individuals and the environment. Any unavoidable radiation exposure and contamination has to be kept as low as possible in line with the state of the art in science and technology, considering all circumstances of each individual case, even below the legal limits. Within the nuclear facilities themselves, the radiation protection supervisor and the radiation protection officers (see Chapter F.1.1 for terms and definitions) are responsible for ensuring that radiation exposure is limited in line with the state of the art in science and technology to protect the population at large, the environment, and the personnel. In connection with the granting of licences and the performance of their supervisory duties, the competent authorities check the provision of radiation protection measures and exposure limits and whether these are adhered to.

According to § 32(5) StrlSchV, the radiation protection officer shall not be hindered in any way in performing his duties or be put at a disadvantage due to performing these duties. The radiation protection officer ensures as part of the preparation of work that the stay of staff in the controlled area is kept as short as possible. If necessary, he checks the measures taken for this purpose himself. He defines the necessary measures of radiation protection and its verification and supervises and documents these. He ensures that all installations and equipment relevant for radiation protection are regularly maintained and inspected. He instructs the staff and ensures that alarm exercises are carried out at regular intervals. Furthermore, he is concerned with the necessary plant-internal emergency measures. To ensure that the radiation protection officer has the technical qualification necessary for his task in accordance with § 30 StrlSchV, he has to acquire the necessary technical qualification according to the Guideline on technical qualification in radiation protection, Appendix A, Technical Qualification Groups [3-40] and take part in refresher courses at intervals of no more than five years.

F.4.3 Radiation exposure of the general public

It is a general rule for all nuclear facilities pursuant to § 46 StrlSchV that from their operation an effective dose of no more than 1 mSv per calendar year may result for members of the general public. Adherence to limits is also taken into account when planning nuclear facilities. A summary of the limits for radiation exposure of the general public and of occupationally exposed persons is given in Table F-1.

Table F-1: Dose limits as defined in the Radiation Protection Ordinance [1A-8]

§	Scope of application	Period	Limit [mSv]
	Design and operation of nuclear facilities		
46	Limitation of the radiation exposure of the general public		
	Effective dose: direct radiation from facilities, including discharges	Calendar year	1
	Organ dose for the lens of the eye	Calendar year	15
	Organ dose for the skin	Calendar year	50
	Dose limits for occupationally exposed persons		
55	Occupationally exposed persons		
	Effective dose	Calendar year	20
	Organ dose for the lens of the eye	Calendar year	150
	Organ dose for skin, hands, forearms, feet, and ankles	Calendar year	500
	Organ dose for gonads, uterus, and red bone marrow	Calendar year	50
	Organ dose for thyroid gland and bone surface	Calendar year	300
	Organ dose for large intestine, lung, stomach, bladder, chest, liver, oesophagus, thyroid gland, and other organs or tissues not named above	Calendar year	150
	Body dose for persons under the age of 18	Calendar year	1
	Apprentices aged 16 – 18, with the permission of the authority	Calendar year	6
	Partial body dose for uterus for women of child-bearing age	Month	2
	Unborn child	from notification of the pregnancy until its end	1
56	Occupational lifetime dose, effective dose	Whole lifetime	400
58	Specially permitted radiation exposure, effective dose (only volunteers of Category A, subject to authorisation by the authority, no pregnant women)	Occupational life	100

In the case of nuclear facilities that are subject to licensing according to §§ 6, 7 or 9 AtG [1A-3] or to the plan approval procedure according to § 9b AtG, such as the pilot conditioning plant (PKA), the Karlsruhe vitrification plant (VEK), the storage facilities for spent fuel and facilities for the disposal of radioactive waste, that radiation exposure for reference persons at the most unfavourable receiving points is determined in their planning to demonstrate compliance with the limits.

For the operation of the nuclear facilities, the permissible discharges to air and water are specified by the competent authority by limiting the concentrations and quantities of radioactivity, taking into account the already existing pollution from other nuclear facilities and from past practices.

On-site storage facilities for spent fuel do not generate any discharges of radioactive waste water, since any contaminated waste water, e.g. from maintenance work on the containers, which exceeds the maximum permitted activity concentrations is transferred to sewage treatment facilities. Discharges into air by releases from the storage casks are not to be expected, although discharge values have been applied for in order to allow for possible contamination of the cask surfaces, for example. In practice, however, discharges to air are negligible due to the leak-tightness criteria for storage casks and the existing rules for surface contamination on the outside of the casks. Radiation exposure due to direct irradiation by gamma and neutron radiation occurs in the immediate vicinity of the storage facilities. In such cases, the aforementioned radiation exposure limits for personnel and the general public must be taken into account.

F.4.4 Measures to prevent unplanned and uncontrolled releases

In order to prevent accidents involving uncontrolled releases of radioactive materials, nuclear facilities must be planned and designed in such a way that the effects caused by them remain limited.

According to § 49 StrlSchV [1A-8], the following requirements apply for the design of on-site storage facilities for spent fuel and for facilities for the disposal of radioactive waste:

- a maximum effective dose of 50 mSv (calculated across all exposure paths, 50-year committed doses and up to age 70 for children from intakes) must not be exceeded in case of the most unfavourable design basis accident through release of radioactive substances into the environment, and
- maximum organ doses for various organs must be taken into account, such as 150 mSv each for the eyes and the thyroid gland, and 300 mSv for bone surfaces.

For the aforementioned types of nuclear facilities, it is necessary to demonstrate already during the licensing procedure that they are designed against certain accidents, the so-called design basis accidents, in accordance with these specifications.

For all other nuclear facilities and installations according to §§ 6(1), 7(1) and 9(1) AtG [1A-3], § 50 StrlSchV applies, also for handling operations according to § 7 StrlSchV if certain amounts of radioactive materials handled are exceeded (see § 50(3) StrlSchV). For such facilities, structural or engineering safeguards are specified by the licensing authority according to the hazard potential and the probability of accidents for the respective facility. Until general administrative provisions on accident prevention enter into force for these facilities, an effective dose of 50 mSv was stipulated for activities according to § 7 StrlSchV in line with § 117(16) StrlSchV for the most unfavourable design basis accident.

For the Asse II mine, the Act on Speeding up the Retrieval Radioactive Waste and the Closure of the Asse II Mine (“Lex Asse“) [1A-26] stipulates that for the planning and closure measures, the accident planning values shall be determined by the licensing authority on a case-by-case basis until general administrative provisions become effective.

The requirements for the confinement of radioactive material in connection with the storage of radioactive waste with negligible heat generation and the storage of spent fuel and heat-generating radioactive waste in casks are presented in two statements of the Nuclear Waste Management Commission (ESK) [4-2], [4-3]. These statements are taken as a basis for the assessment of storage facilities already existing and yet to be constructed and emphasise the high level of protection of the respective casks that these can provide according to their design.

F.4.5 Limitation of operational discharges of radioactive substances

Basis

Radioactive substances must not be discharged into the surrounding environment of a nuclear facility in an uncontrolled manner. Their operational discharges to water or air must be monitored and registered according to specific type and activity. The discharge values specified by the competent authority in the plant's licence are to be observed with regard to concentration and quantity of radioactivity. As a rule, the actual values fall well below these limits.

The radiation exposure for reference persons is already determined during the planning of nuclear facilities in order to determine the permissible discharge values at the most unfavourable receiving points. The calculation method for the determination of the radiation exposure is laid down in a general administrative provision [2-1]. A detailed guideline exists for the performance of emission and immission monitoring [3-23].

Monitoring of emissions and immissions during specified normal operation and in case of design basis accidents

Discharges from nuclear facilities must be monitored, specified by activity and type and these data reported to the competent authority at least once a year.

The supervisory authority responsible for the nuclear facility may order measures supplementary to monitoring, or in individual cases may exempt the facility operator from this reporting obligation, provided he can prove by demonstrating the confinement of the radioactive materials or by the small radioactive inventory and the type of work to be carried out within the facility that the limits to be kept will be reliably adhered to. This applies in particular to handling of nuclear material to be licensed under § 7 StrlSchV [1A-8], such as some of the conditioning facilities and storage facilities for radioactive waste in which no repairs are carried out. Compared to nuclear power plants, these facilities only have little or, in individual cases, no discharges of radioactive substances.

For nuclear facilities and installations subject to licensing or plan approval according to §§ 6, 7, or 9b AtG [1A-3], such as the PKA, the VEK, the storage facilities for spent fuel, a few conditioning facilities for the treatment of nuclear fuel, and facilities for the disposal of radioactive waste, the determination of meteorological and hydrological dispersion conditions may additionally be required.

It should be taken into account that the PKA, in which the spent fuel assemblies are to be dismantled and conditioned to meet the requirements for disposal, for the time being will only be used to repair damaged spent fuel casks until selection of a repository site. At present, discharges do not have to be considered here.

The Guideline concerning Emission and Immission Monitoring of Nuclear Installations (REI) [3-23] contains specifications on the harmonisation of monitoring and the performance thereof. The holder of the licence is responsible for monitoring in the form of self-monitoring. Independent institutions conduct reference measurements on behalf of the competent supervisory authority.

Appendix C of the REI [3-23] contains supplementary specific regulations for storage facilities for spent fuel and facilities for the disposal of radioactive waste. For spent fuel storage facilities it stipulates that emission monitoring is not required if tightness and integrity of the spent fuel casks have been demonstrated and are monitored continuously. Monitoring of environmental immissions from dry storage facilities is to be regulated such that the monitoring of contributions to the total dosage from direct radiation of the nuclear facility is ensured.

F.4.6 Clearance

Overview

Radioactive residues are produced in nuclear facilities, in particular during the decommissioning phase, as well during the operation of facilities for the treatment of radioactive substances and spent fuel, whose activities per unit mass or area – after decontamination, if necessary – are low. These residues can be released from nuclear monitoring. The criterion for this is an effective dose in the range of 10 µSv/a for members of the public, as laid down in § 29(2) StrlSchV [1A-8] in accordance with the provisions of Council Directive 96/29/EURATOM [1F-18]. Cleared materials are mainly building rubble, scraps, operational waste as well as other solid substances and liquids from the dismantling or repair of nuclear facilities. Clearance procedures are also applied for buildings as well as site areas (soil areas) of facilities.

For clearance, various clearance options are available, which are described in § 29(2)1 and 2 StrlSchV in conjunction with requirements outlined in Appendix IV StrlSchV. Important clearance options include the unrestricted clearance of all types of solid or liquid substances, as well as rubble and soil areas, clearance for disposal (in a landfill or in a thermal waste treatment plant as for conventional waste of other origin), the clearance of metal scrap for recycling and the clearance of buildings for demolition or subsequent use.

Insofar as specific provisions of the StrlSchV on clearance are not available or no clearance levels have been defined in the StrlSchV, compliance with an effective dose in the range of 10 µSv/a for members of the public is to be demonstrated on a case-by-case basis. In such cases, the dose is determined on the basis of specific boundary conditions relating to the site of the intended use, recycling or disposal of the material.

Deliberate mixing or dilution of the materials in order to achieve clearance is not permitted.

Clearable materials

Residues produced in the controlled areas of nuclear facilities are considered to be potentially radioactive and must initially not leave the radiation protection areas. Once these residues show a sufficiently low activity (after decontamination, if necessary), they can be prepared for clearance. This concerns, in particular,

- metals (ferrous and non-ferrous metals) from facility components or parts thereof, piping, reinforcements, etc.,
- rubble from the demolition of buildings, and
- insulation material, cables, etc.

The further use or recycling of cleared objects and materials is common practice. Examples are

- reuse of tools, lathes, tool cabinets, but also shielding blocks, steel girders or the like in civil engineering projects,
- recycling of metals for the production of waste containers for radioactive waste, but also for unrestricted conventional recycling (e.g. steel, aluminium, copper),
- use of rubble for building of roads and landfill sites,
- use of other materials (electronic scrap, cables, etc.) in its respective resource cycle, and

- reuse of equipment and components from nuclear power plants in other nuclear power plants.

With progressing dismantling of a nuclear facility, the clearance of buildings and eventually also of the site will become relevant.

Clearance options and clearance levels

§ 29 StrlSchV [1A-8] specifies various clearance options, drawing a distinction between unrestricted clearance and clearance for removal, demolition of buildings or the recycling of metal scrap:

In the case of unrestricted release, the substances can freely be used after clearance from a radiological point of view. The following four clearance options are available:

- unrestricted clearance of (solid or liquid) substances that may afterwards be reused, recycled or also disposed of,
- unrestricted clearance of rubble and excavated soil of more than 1,000 Mg/a that after clearance may be used for any chosen purpose, e.g. for the backfilling of excavations, as road bedding, etc.,
- unrestricted clearance of buildings that afterwards may be demolished or also be reused,
- unrestricted clearance of soil areas that may subsequently be used for any purposes, e.g. for the construction of houses and apartment buildings, industrial buildings, etc.

Other clearance options are:

- clearance of solid substances for disposal in a (conventional) landfill with masses of up to 100 Mg/a and up to 1,000 Mg/a, respectively,
- clearance of (solid or liquid) substances for removal in an incinerator with masses of up to 100 Mg/a and up to 1,000 Mg/a, respectively,
- clearance of buildings for demolition, with any conventional use of the buildings prior to their demolition being impermissible,
- clearance of scrap metal for recycling by smelting in a conventional melting shop, e.g. a foundry, a steel works, etc.

For these clearance options, clearance levels are shown in Appendix III, Table 1 StrlSchV. Table F-2 shows examples of these clearance levels for a selection of radionuclides that are of importance in connection with the decommissioning and dismantling of nuclear facilities. The respective clearance levels are given as values per unit mass or area (Bq/g and Bq/cm², respectively). This depends on the type of measurement to be carried out for demonstrating compliance with these clearance levels.

Table F-2: Examples of clearance levels according to Appendix III, Table 1 StrlSchV a): Options for unrestricted clearance, b): Options for clearance for a specific purpose

a) Options for unrestricted clearance

	Exemption level			Unrestricted clearance of:				
Radionuclide	Activity	Specific activity	Surface contamination	Solid substances, liquids with the exception of Column 6	Building rubble, excavated soil of more than 1,000 Mg/a	Soil areas	Buildings for reuse or further use	Half-lives
	[Bq]	[Bq/g]	[Bq/cm²]	[Bq/g]	[Bq/g]	[Bq/g]	[Bq/cm²]	[a]
1	2	3	4	5	6	7	8	11
H-3	$1 \cdot 10^{09}$	$1 \cdot 10^{06}$	100	$1 \cdot 10^{03}$	60	3	$1 \cdot 10^{03}$	12.3
C-14	$1 \cdot 10^{07}$	$1 \cdot 10^{04}$	100	80	10	0.04	$1 \cdot 10^{03}$	$5.7 \cdot 10^{03}$
Cl-36	$1 \cdot 10^{06}$	$1 \cdot 10^{04}$	100	0.3	0.3		30	$3.0 \cdot 10^{05}$
Fe-55	$1 \cdot 10^{06}$	$1 \cdot 10^{04}$	100	200	200	6	$1 \cdot 10^{03}$	2.7
Co-60	$1 \cdot 10^{05}$	10	1	0.1	0.09	0.03	0.4	5.3
Ni-63	$1 \cdot 10^{08}$	$1 \cdot 10^{05}$	100	$3 \cdot 10^{02}$	$3 \cdot 10^{02}$	3	$1 \cdot 10^{03}$	100.0
Sr-90+	$1 \cdot 10^{04}$	$1 \cdot 10^{02}$	1	0.6	0.6	$2 \cdot 10^{-03}$	30	28.5
Ag-108m+	$1 \cdot 10^{06}$	10	1	0.2	0.1	$7 \cdot 10^{-03}$	0.5	127.0
Ag-110m+			1	0.1	0.08	0.007	0.5	0.68
I-129	$1 \cdot 10^{05}$	$1 \cdot 10^{02}$	1	0.06	0.06		8	$1.6 \cdot 10^{07}$
Cs-137+	$1 \cdot 10^{04}$	10	1	0.5	0.4	0.06	2	30.2
Eu-152	$1 \cdot 10^{06}$	100	1	0.2	0.2	0.07	0.8	13.3
Eu-154	$1 \cdot 10^{06}$	10	1	0.2	0.2	0.06	0.7	8.8
U-238+	$1 \cdot 10^{04}$	10	1	0.6	0.4		2	$4.4 \cdot 10^{09}$
Pu-238	$1 \cdot 10^{04}$	1	0.1	0.04	0.08	0.06	0.1	87.7
Pu-241	$1 \cdot 10^{05}$	$1 \cdot 10^{02}$	10	2	2	4	10	14.4
Am-241	$1 \cdot 10^{04}$	1	0.1	0.05	0.05	0.06	0.1	432.6

b) Options for clearance for a specific purpose

	Exemption level		Clearance of:						
Radionuclide	Activity	Specific activity	Solid substances up to 100 Mg/a to be disposed of in landfills	Solid substances and liquids up to 100 Mg/a for removal in incinerators	Solid substances up to 1,000 Mg/a to be disposed of in landfills	Solid substances and liquids up to 1,000 Mg/a for removal in incinerators	Buildings for demolition	Scrap metal for recycling	Half-lives
	[Bq]	[Bq/g]	[Bq/g]	[Bq/g]	[Bq/g]	[Bq/g]	[Bq/cm^2]	[Bq/g]	[a]
1	2	3	9a	9b	9c	9d	10	10a	11
H-3	$1 \cdot 10^{09}$	$1 \cdot 10^{06}$	$6 \cdot 10^{04}$	$1 \cdot 10^{06}$	$6 \cdot 10^{03}$	$1 \cdot 10^{06}$	$4 \cdot 10^{03}$	$1 \cdot 10^{03}$	12.3
C-14	$1 \cdot 10^{07}$	$1 \cdot 10^{04}$	$4 \cdot 10^{03}$	$1 \cdot 10^{04}$	$4 \cdot 10^{02}$	$1 \cdot 10^{04}$	$6 \cdot 10^{03}$	80	$5.7 \cdot 10^{03}$
Cl-36	$1 \cdot 10^{06}$	$1 \cdot 10^{04}$	3	3	0.3	0.3	30	10	$3.0 \cdot 10^{05}$
Fe-55	$1 \cdot 10^{06}$	$1 \cdot 10^{04}$	$1 \cdot 10^{04}$	$1 \cdot 10^{04}$	$7 \cdot 10^{03}$	$1 \cdot 10^{04}$	$2 \cdot 10^{04}$	$1 \cdot 10^{04}$	2.7
Co-60	$1 \cdot 10^{05}$	10	6	7	2	2	3	0.6	5.3
Ni-63	$1 \cdot 10^{08}$	$1 \cdot 10^{05}$	$1 \cdot 10^{04}$	$6 \cdot 10^{04}$	$1 \cdot 10^{03}$	$6 \cdot 10^{03}$	$4 \cdot 10^{04}$	$1 \cdot 10^{04}$	100.0
Sr-90+	$1 \cdot 10^{04}$	$1 \cdot 10^{02}$	6	40	0.6	4	30	9	28.5
Ag-108m+	$1 \cdot 10^{06}$	10	9	10	1	1	4	0.8	127.0
Ag-110m+			6	6	2	0.6	4	0.5	0.68
I-129	$1 \cdot 10^{05}$	$1 \cdot 10^{02}$	0.6	0.6	0.06	0.06	8	0.4	$1.6 \cdot 10^{07}$
Cs-137+	$1 \cdot 10^{04}$	10	10	10	8	3	10	0.6	30.2
Eu-152	$1 \cdot 10^{06}$	10	10	10	4	4	6	0.5	13.3
Eu-154	$1 \cdot 10^{06}$	10	10	10	4	4	6	0.5	8.8
U-238+	$1 \cdot 10^{04}$	10	6	10	0.6	5	10	2	$4.4 \cdot 10^{09}$
Pu-238	$1 \cdot 10^{04}$	1	1	1	1	1	3	0.3	87.7
Pu-241	$1 \cdot 10^{05}$	$1 \cdot 10^{02}$	100	100	40	100	90	10	14.4
Am-241	$1 \cdot 10^{04}$	1	1	1	1	1	3	0.3	432.6

* The figures in the fourth line refer to the column numbering acc. to Appendix III, Table 1 StrlSchV.

Once clearance is completed and the material has left the scope of supervision under nuclear law, the provisions of waste management law apply [1B-13].

Basis for clearance

The clearance levels are based on comprehensive studies that have been initiated by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) as part of the implementation of Council Directive 96/29/EURATOM, on recommendations of the Commission on Radiological Protection (SSK) and publications of the European Commission. In 2011, the clearance levels for landfill disposal and incineration of waste have been modified due to changes in boundary conditions of waste management law [1A-8].

Council Directive 2013/59/EURATOM is currently being transposed into German law. A major change is the equalisation of exemption levels and clearance levels for the unrestricted clearance of solids. A new set of clearance levels for solids is specified. As a result of this, the clearance levels for the unrestricted clearance of solids will in part be increased, in part reduced compared to today's levels. The existing clearance concepts can, however, be largely retained, with the exception of a few adjustments.

F.4.7 Measures to control releases and mitigate their effects

Basis

§ 51 StrlSchV [1A-8] stipulates that in the event of radiological emergency situations, all necessary measures shall be initiated without delay in order to limit dangers to man and the environment to a minimum. Furthermore, there is an obligation to report to the nuclear supervisory authority and, if necessary for the protection of the population against risks to life and health, also to the authority responsible for public safety as well as to the authorities responsible for disaster control.

In radiological emergency situations, the competent authorities will notify the potentially affected population without delay and issue protective action instructions in such situations. The reporting on Article 25 in Chapter F.5 gives an overview of the emergency measures to be taken in relation to the hazard potential of the nuclear facility.

The procedure at the facility in the event of an unplanned and uncontrolled release of radioactive substances into the environment must be specified in an operating manual (see reporting on Article 9). The latter must include fire safety regulations and an alarm code. In this context, safety standard KTA 1201 is to be applied mutatis mutandis (see Safety Standards of the Nuclear Safety Standards Commission (KTA) in Annex L-(d)). The fire safety regulations must specify measures of preventive and defensive fire protection. The alarm code has to outline measures and protective action instructions for events posing a potential threat to staff and the surrounding area of the facility, as well as information on alarm drills and escape routes. Furthermore, the operating manual has to outline the measures initiated automatically and those which must be initiated manually by the staff on shift in case of an accident. It also has to specify the criteria under which it is to be assumed that important safety functions are not performed by the systems as designed and on-site emergency measures have to be taken, addressing the incidents defined in the licensing procedure.

Integrated Measuring and Information System

Besides the monitoring of emissions and immissions at the site of a nuclear facility, there is also the Integrated Measuring and Information System for Monitoring Environmental Radioactivity (IMIS) according to § 163 StrlSchG [1A-29b], which ensures comprehensive monitoring of environmental radioactivity throughout the territory of the Federal Republic of Germany. The respective responsibilities of the Federation and the *Länder* are specified under §§ 161 and 162 StrlSchG together with the corresponding information system. The IMIS general administrative provision (AVV-IMIS) [2-4] regulates the overall complex of environmental monitoring, with two appendices – the routine measuring schedule and the intensive measuring schedule – defining the measuring scopes and measuring methods for normal conditions and for incidents.

The federal authorities conduct comparative measurements and analyses uniformly throughout the country and develop sampling, analysis, and measurement techniques. The German National Metrology Institute (PTB) provides radioactivity standards for reference measurements.

The IMIS comprises an automatic measurement network consisting of more than 1,800 stationary measurement stations for monitoring the local gamma dose rate and measurement networks for determining the activity concentration in the air, precipitation, and the aqueous environment. In addition, the radioactivity in food, feed, drinking water as well as in residual substances and waste waters is determined. Centralised data logging is performed at the Federal Central Station for Monitoring Environmental Radioactivity at the BfS in Neuherberg. The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) evaluates the data. In the event of an accident or emergency with radiological consequences for the German territory, the BMUB will initiate the activation of intensive operation of the monitoring system according to the

AVV-IMIS and alerts the *Länder*. Furthermore, the BMUB recommends actions to be taken to protect the population after consultation with the *Länder*.

F.5 Article 25: Emergency preparedness

> ***Article 25: Emergency preparedness***
>
> *(1) Each Contracting Party shall ensure that before and during operation of a spent fuel or radioactive waste management facility there are appropriate on-site and, if necessary, off-site emergency plans. Such emergency plans should be tested at an appropriate frequency.*
>
> *(2) Each Contracting Party shall take the appropriate steps for the preparation and testing of emergency plans for its territory insofar as it is likely to be affected in the event of a radiological emergency at a spent fuel or radioactive waste management facility in the vicinity of its territory.*

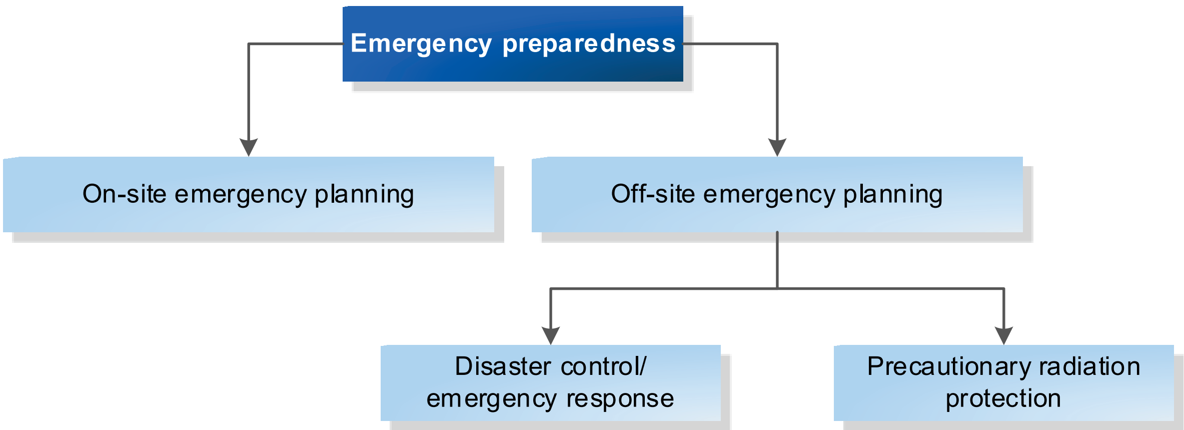
F.5.1 On-site and off-site emergency plans for nuclear facilities

Basis

In Germany, a concept of nuclear emergency preparedness has been established which is geared primarily towards nuclear power plants. However, the related rules are generally applicable to any nuclear facility, while the effort can be reduced according to the lower hazard potential compared to that of nuclear power plants.

Nuclear emergency preparedness comprises on-site and off-site planning and preparedness for emergencies (see Figure F-3).

Figure F-3: Structure of emergency preparedness



On-site emergency planning is realised by technical and organisational measures taken at nuclear installations to control an event or to mitigate its consequences.

In the case of off-site emergency planning, a distinction was made between disaster control and precautionary radiation protection as at the reference date of this national report, which is aimed at protecting against the effects of large-scale dispersion of radioactivity. In this respect, the *Länder* are responsible for disaster control and the related disaster control measures and the Federation mainly for precautionary radiation protection and the related measures. The two areas of disaster control and precautionary radiation protection do not compete but complement each other, albeit with overlapping boundaries. Some of the most important changes resulting from the Act on the Protection against the Harmful Effects of Ionising Radiation (Radiation Protection Act – StrlSchG) [1A-29b] promulgated after the reference date of this national report are presented in Chapter F.5.3 below.

In the light of the accident sequence in the Fukushima nuclear power plant, the Federal Office for Radiation Protection (BfS) conducted studies on off-site emergency preparedness and response in Germany. The results of these studies have been incorporated into the recommendations of the Commission on Radiological Protection (SSK) on the further development of the radiological emergency protection as well as into the new Radiation Protection Act.

Regulatory basis

Based on the protective provisions of the Atomic Energy Act (AtG) [1A-3] and § 51 of the Radiation Protection Ordinance (StrlSchV) [1A-8], the operator is responsible, within the framework of on-site emergency planning, to keep the risk of potential hazards for man and the environment as low as possible in case of incidents and accidents.

According to § 12(7) AtG and § 51(1) StrlSchV, the operator of any nuclear facility shall be obliged to communicate any safety-relevant deviations from specified normal operation, particularly accidents, incidents or radiological emergency situations, to the competent supervisory authority without delay and, if necessary, to also inform the authority responsible for public security and the authority responsible for disaster control in the *Land* concerned.

The criteria which when reached require alerting the disaster control authorities are based on a joint recommendation of the Reactor Safety Commission (RSK) and the SSK on criteria for alerting the disaster control authority by the operator of a nuclear facility [SSK 13], last amended in February 2013.

According to § 53 StrlSchV, no special emergency preparedness measures are required for a nuclear facility if the activity of the radioactive substances handled there does not exceed certain limits. These thresholds are:

1. 10^{07} times the exemption levels for activity according to Appendix III, Table 1, Column 2 StrlSchV in the case of unsealed radioactive substances,
2. 10^{10} times these exemption levels in the case of sealed radioactive substances.

Accordingly, some of the radioactive waste management facilities do generally not require emergency planning since the possibility of safety-relevant events can be excluded. This usually concerns the handling of radioactive material subject to licensing under § 7 StrlSchV [1A-8].

Within the German Federal Government, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) is responsible for the provision of general criteria for the preparation of emergency plans for the vicinity of nuclear facilities.

To assess the need for measures of disaster control/emergency response and precautionary radiation protection in case of accidents in nuclear facilities in Germany and abroad, a catalogue of measures of the BMUB is available with an overview of measures for the mitigation of radiological exposure following incidents or accidents with non-negligible radiological consequences [BMU 08].

In accordance with the provisions of Council Directive 89/618/EURATOM [1F-29], § 51(2) StrlSchV specifies that the affected population must be informed without delay of a radiological emergency situation and any special measures to be taken which may be required on their part. The individual disaster control authorities jointly agree and coordinate the process of notifying the general public.

As part of emergency preparedness, disaster control measures may be initiated. For this purpose, the following can be referred to:

1. basic recommendations for disaster control in the vicinity of nuclear facilities, and
2. radiological basis for decisions on measures to protect the population in events with releases of radionuclides [4-21].

With regard to the radiological basis for the recommendation of disaster control measures in [3-15], fixed numerical values for recommended intervention reference levels have been adopted, based on the recommendations in publications No. 103 and No. 109 of the International Commission on Radiological Protection (ICRP) ([ICRP 07] and [ICRP 09]) and the International Basic Safety Standards of the International Atomic Energy Agency (IAEA) [IAEA 14a], which are designed to facilitate decision-making at the start of measures and which can be adjusted later on if necessary (see Table F-3). This is consistent with the approach adopted by the European Commission.

Table F-3: Intervention reference levels for the measures of sheltering, taking iodine tablets, evacuation as well as temporary and long-term resettlement from [3-15]

Measure	Intervention reference levels		
	Organ dose (thyroid)	Effective dose	Organ dose (thyroid)
Sheltering		**10 mSv**	External exposure over 7 days and committed effective dose due to radionuclides inhaled within this period
Taking iodine tablets	**50 mSv** Children and adolescents under age 18 and pregnant women **250 mSv** Persons of age 18 to 45		Radioactive iodine inhaled within 7 days
Evacuation		**100 mSv**	External exposure over 7 days and committed effective dose due to radionuclides inhaled within this period
Temporary resettlement		**30 mSv**	External exposure within 1 month
Long-term resettlement		**100 mSv**	External exposure within 1 year due to radionuclides deposited on the ground

For immediate decision-making, dose intervention reference levels are supplemented by measurable parameters, the so-called “derived reference levels”.

Suitable parameters are:

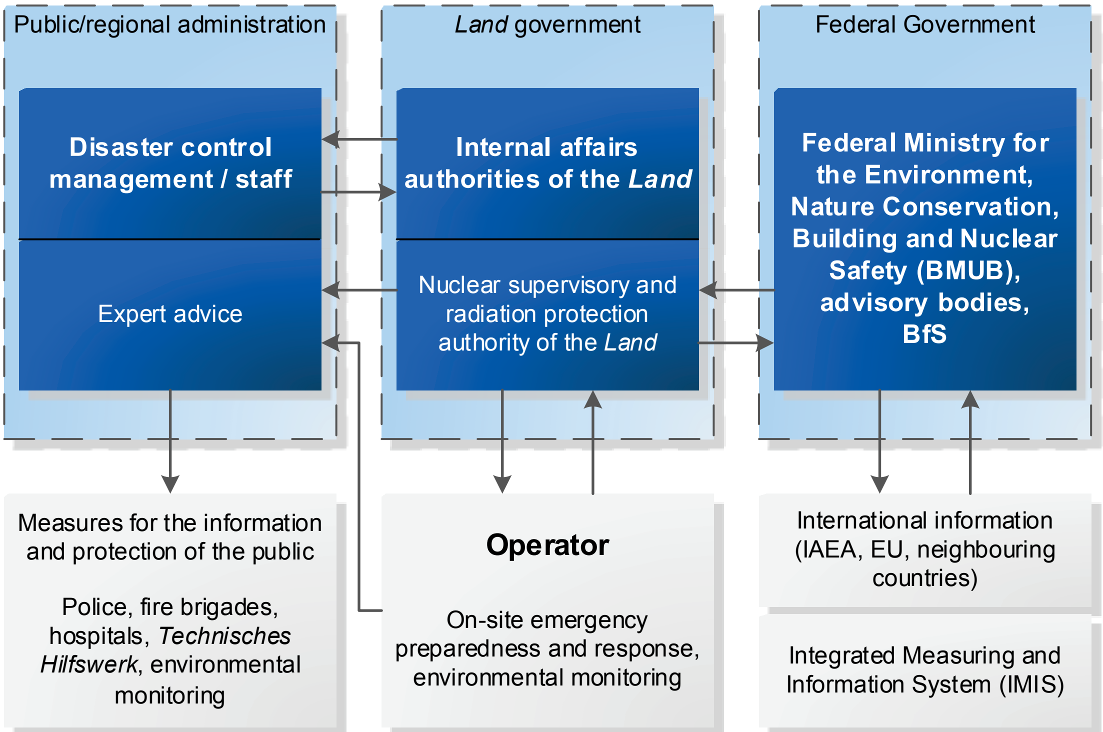
- local dose rate,
- (time-integrated) activity concentrations in the air, and
- surface contamination (ground, objects, skin).

Extensive measures of off-site emergency planning, e.g. preparation of an off-site emergency plan, may not be required if the calculated effective doses for design basis accidents and events with low occurrence probability in the vicinity of a facility are significantly below the limit values of radiation exposure after design basis accidents as defined in §§ 49 and 50 StrlSchV [1A-8]. The decisions are taken by the competent licensing and supervisory authorities for the nuclear facilities in the *Land* concerned.

Organisation

Emergency preparedness is organised in cooperation between the Federal Government and the governments of the *Länder*, regional authorities, the police, the governmental disaster relief organisation (Technisches Hilfswerk), fire brigades, hospitals, and the operator of the nuclear facility. While the operator is responsible for on-site emergency preparedness, off-site emergency preparedness outside the facility is the responsibility of the *Land* authorities (as part of disaster control). Temporally and geographically limited disaster control measures are coordinated and performed by the *Land* authorities, the regional authorities, and in particular the management of the disaster control services (see Figure F-4). This requires a precise knowledge of the state of the facility and an evaluation of the radiological situation and the situation in the areas affected.

Figure F-4: Organisation of emergency preparedness



<u>Tasks of the Federation and the *Länder*</u>

Where required, the BMUB makes its resources, including those of the BfS or its advisory bodies, available for providing support and advice to the *Länder*.

The basic recommendations for disaster control are prepared under the leadership of the BMUB and involvement of the *Länder*.

Within the framework of precautionary radiation protection, the Federation is authorised to specify limits and measures. However, as far as events with exclusively regional impact are concerned, the *Land* authority competent for precautionary radiation protection may determine measures to be taken for preventive health protection. By means of the Integrated Measuring and Information System (IMIS) for the monitoring of environmental radiation, the Federal Government monitors and assesses the radiological situation in Germany both during routine operation and under incident and accident conditions (see reporting on Article 24). Where required, the data are transmitted to the corresponding federal and regional disaster control authorities and the measuring and data transmission frequency of the IMIS will be increased.

In the event of a radioactive release abroad with an impact on German territory, alerting of the *Länder* is ensured on the one hand by the Federation which is informed on the basis of bilateral and international agreements if an event occurs, and on the other hand in parallel by the IMIS.

It is the task of the competent *Land* authority to specify the nature and scope of emergency preparedness and response, taking into account the specific requirements of the respective nuclear facility. The criteria for the nature and scope of emergency planning are determined in particular by the radioactive inventory and the occurrence probability of an incident or accident.

The individual *Länder* designate the authority responsible for disaster control. In accordance with the Disaster Control Act of the particular *Land*, alarm and action plans must be drawn up and updated by this authority, if required, to serve as off-site emergency plans for the nuclear facilities within its jurisdiction. In these plans, all measures are specified that are provided by the disaster control authority in the event of accidents or incidents in the respective facility.

The competent authority for disaster control of a nuclear facility has to nominate an expert radiation protection consultant to the disaster response management. This person collects, verifies and assesses all information relevant in connection with an event and advises the disaster response management regarding the radiological situation. The work of this person is based on the Guideline for the expert radiation protection consultant [SSK 04a], [SSK 04b], which is to be applied mutatis mutandis in accordance with the specific requirements of a particular nuclear facility.

For the preparation of off-site emergency plans, the disaster control authorities refer to the basic recommendations, the corresponding provisions under disaster control law of the respective *Land*, and the responsibility assignment plans regulating the cooperation among the different *Land* authorities. The off-site emergency plans show the competences and responsibilities for on-site management, for crisis team management, for the alerting criteria as well as for the definition of the necessary measures.

To limit the extent of preparatory measures, the surrounding area of a facility is divided into three zones:

- Inner zone in which, in particular, the measures "sheltering", "intake of iodine" and "evacuation" are to be prepared for the protection of the population. The evacuation of the entire population of the inner zone as well as the distribution of iodine tablets to these persons should be completed 6 hours after the alert of the competent authorities.

- Middle zone in which, in particular, the measures "sheltering", "intake of iodine" and "evacuation" are to be prepared. The evacuation of the intermediate zone should be possible within 12 hours. Within this time, the distribution of iodine tablets to the persons for whom thyroid blocking is to be conducted should also be completed.

- Outer zone in which measures for the determination and monitoring of the radiological situation are prepared. In addition to the measurement programmes, the measure "sheltering" as well as the distribution of iodine tablets to the persons for whom thyroid blocking is to be conducted is to be prepared.

In the entire territory of Germany, measures are to be taken to carry out measuring programmes to determine the radiological situation and to prepare supply of iodine tablets to children and adolescents under 18 as well as pregnant women.

Within a radius of 25 km around nuclear power plants, the *Länder* are responsible for the distribution of iodine tablets for thyroid blocking. Depending on the planning of the individual *Land*, these are stored decentralised at fire stations, town halls, pharmacies or known polling stations for the case of an event. In Germany, iodine tablets are stored in eight central stores of the Federation and, if required, made available to the *Länder* for thyroid blocking. The aim is that iodine tablets can be provided to every citizen within eight hours, regardless of the time of day or weather.

Taking into consideration the safety report of the plant, the on-site emergency plan and other information from the operator, as well as in consultation with the competent supervisory authority, the disaster control authority may decide that it is not necessary to draw up an off-site emergency plan. In such cases, potential accidents are covered by the measures for general disaster control which must be planned regardless of the hazard potential of specific facilities. This waiving of off-site emergency planning must be justified in detail by the authority.

If an off-site nuclear emergency plan is drawn up for a nuclear facility, this has to be continuously updated and reviewed at regular intervals. At intervals of several years, the authorities carry out disaster control exercises at the sites of the nuclear facilities in order to verify the efficiency of the emergency plans and identify weak points (see Figure F-5). The operators also take part in these exercises. § 53(5) StrlSchV [1A-8] stipulates that the population has to be informed periodically every five years about the emergency planning.

Figure F-5: GNS fire brigade during a fire drill at the Gorleben site (Copyright: GNS)

Tasks of the operator

The operator develops the on-site emergency plan in the emergency manual and the alarm code as part of the operating manual and must keep them up to date. In particular, emergency planning has to regulate: duties and responsibilities, alerting criteria and for taking internal measures, the information flow to the crisis team and to the disaster control authority, and special stipulations for the emergency staff of the facility.

Furthermore, according to § 53 StrlSchV [1A-8], the operator must have trained personnel and any tools which may be required on hand for controlling emergency situations, and must provide the authorities responsible for emergency preparedness and response with the information necessary to deal with an incident. He must assist the competent authorities in planning emergency measures and inform them of possible risks when deploying helpers and of protective measures required.

The operator alerts the disaster control service of the competent *Land* authority in case of an emergency situation or if there are concerns that such a situation may occur. He recommends to the disaster control service which level of alarm should be raised, either an early warning or an emergency alert.

Specifically for the case of fire fighting, the operator must coordinate necessary measures in advance in cooperation with the competent *Land* authorities, the fire service, or the mine rescue service (in the case of repositories). In this respect, it is particularly important to clarify the special equipment required for fighting fires in the individual areas of the facility.

Implementation for the individual facilities

The central storage facilities for spent fuel at Ahaus and Gorleben, the Zwischenlager Nord (ZLN) and the storage facility at Jülich are not subject to any special nuclear emergency planning, despite the fact that their radioactivity inventories exceed the limits given in § 53 StrlSchV [1A-8]. On-site emergency plans exist for all central storage facilities. Since the individual spent fuel casks are already designed to withstand external hazards, a safety-related event involving releases that would necessitate emergency protection measures need not be postulated, neither for the case of a design basis accident nor for very rare events such as an aircraft crash or a blast wave caused by an explosion. Studies have shown that the values obtained lie well below the accident planning levels according to § 49 StrlSchV. Disaster control falls under the general disaster control planning of the *Land* authorities.

In principle, the same applies for on-site storage facilities at nuclear power plants as for the central storage facilities for spent fuel. However, these facilities are already covered by the extensive emergency planning of the nuclear power plants.

The pilot conditioning plant (PKA) at Gorleben will not require special measures of off-site emergency planning if it becomes operational. The cell wing of the facility is designed against external impacts, in particular against aircraft crashes. In the wing housing the cask storage area, protection is ensured by the design of the type B casks. Other accidents involving significant releases were analysed. They do not lead to any consequences requiring special emergency planning.

No specific emergency plans are needed for the Morsleben repository for radioactive waste (ERAM) in view of the safety-relevant events conceivable there.

For the Asse II mine, special emergency measures are planned in order to limit potential radiation exposures in the long term for the case of a beyond-design solution inflow. These are measures to establish emergency preparedness, precautionary measures to reduce occurrence probability, and measures to be taken in the event of an impending beyond-design solution inflow (flooding).

Measures to establish emergency preparedness have been and are being implemented successively. These include increasing the capacity of discharging inflowing solution to the surface to up to 500 m³ per day as well as the contractual assurance of a disposal option. Above ground and underground, emergency storage facilities were established to ensure replacement of failed devices and equipment and additional equipment provided for an emergency (see Figure F-6).

Figure F-6: Underground material storage at the 490 m level for an emergency in the Asse II mine (Copyright: BfS)

The precautionary measures to reduce the probability of occurrence include the collection of solutions above the emplacement chambers, backfilling of cavities, and the construction of seal structures at the floor level below the emplacement chambers. As part of emergency preparedness, numerous residual cavities at the 775 m level below the emplacement chambers as well as several blind shafts were already backfilled with Sorel concrete. It is also planned to dismantle and backfill cavities in the mine no longer needed (galleries and infrastructure rooms) and to seal cavities and access roads in the vicinity of the emplacement chambers. The measures will counteract the progressive damage to the rock. In addition, the possible release of radionuclides in an emergency is minimised and delayed, which mitigates the effects of a beyond-design solution inflow. With the sealing of a southbound drift at the 750 m level, the last accessible connection between the mine and the adjoining rock being susceptible to inflow was closed in January 2013.

Emergency measures to be taken when leaving the mine are prepared. This includes, among others, the backfilling of residual cavities in the emplacement chambers in case of emergency. Also the so-called cross-flooding, i.e. filling the mine with a saturated magnesium chloride solution, and the sealing of day shafts with Sorel concrete are among the measures that need to be taken in case of emergency.

F.5.2 Emergency plans for the case of incidents in nuclear facilities of neighbouring states

The basic recommendations for disaster control in the vicinity of nuclear facilities [3-15] also apply to foreign nuclear facilities requiring planning measures on German territory due to their proximity to national borders. Permissible discharges during normal specified operation and in case of design basis conditions are a matter at discretion of the respective country's own legislation. In Germany, international regulations were taken into account when defining the limits in the StrlSchV.

The precautions in case of accidents in waste management facilities in neighbouring countries correspond to those applicable to other nuclear facilities, such as nuclear power plants. In order to determine the measures necessary under the Precautionary Radiation Protection Act [1A-5], a catalogue of measures [BMU 08] is applied which includes the necessary instructions on estimating the consequences and on planning measures to be taken.

On the basis of bilateral agreements, the authorities of neighbouring countries are involved in exercises in plants near the border, at least as observers, but usually as active participants. In addition, Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) officials are involved in European Union (EU) and OECD/NEA exercises (INEX exercises) in order to gather relevant international experiences with a view to updating emergency planning in Germany.

Since the early 1980s, the Federal Republic of Germany has entered into bilateral agreements with all neighbouring states, and some countries further away, regarding mutual assistance in case of disasters or major accidents ([1D-1], [1D-2], [1D-3], [1D-4], [1D-5], [1D-8], [1D-9]). These agreements specify the responsibilities and points of contact, guarantee cross-border traffic of personnel and resources deployed, and stipulate mutual exclusion of liability in case of personal injury or property damage, and agree a comprehensive exchange of information and experiences. In the years following German reunification, agreements were also signed with Poland [1D-10], Hungary [1D-6], Lithuania [1D-7] and Russia [1D-11] as well as treaty agreed with the Czech Republic [1D-12].

Germany also has an agreement with France on the exchange of information in case of events or accidents with radiological effects dating from 1981, and an administrative agreement without binding effect under international law dating from 1976.

In 2013, the Federal Republic of Germany joined the Response and Assistance Network (RANET) of the IAEA. In the event of a nuclear or radiological event, RANET offers the possibility to quickly access existing assistance capacities in other countries. German support services include, in particular, assistance in patient treatment in case of a radiation accident, dose determination and dose estimation, dispersion calculations, determination of radiological situations, and the provision of measuring capacities and specialist knowledge. The offer includes both support provided from Germany as well as support in the country of accident itself.

In addition, there are agreements with neighbouring states on the exchange of information and experience in connection with safety engineering or radiation protection, all of which were concluded before 1985 [BMU 13]. There is also a superordinate European regime governing radiological emergencies.

F.5.3 Further development of the emergency management system of the Federation and the *Länder* by the Act on the Reorganisation of the Law on the Protection Against the Harmful Effects of Ionising Radiation

After the reference date of this national report, the Act on the Reorganisation of the Law on the Protection Against the Harmful Effects of Ionising Radiation (Radiation Protection Act – StrlSchG) [1A-29b] was adopted and promulgated. It serves to implement Council Directive 2013/59/EURATOM [1F-24] and reconceptualises the legal and administrative framework for the prevention and management of nuclear accidents and other radiological emergencies in the light of experience gained from the reactor accident in Fukushima. In view of the considerable extension of the scope of application and the significance of the radiation protection law for the protection of human health, the principal provisions for the protection against the harmful effects of ionising radiation were included for the first time in a separate formal law adopted by the *Bundestag* with the consent of the *Bundesrat* and numerous other legal provisions adapted to the new Radiation Protection Act (see Chapter E.2.2 for details on the Radiation Protection Act).

The main innovation in the area of emergency preparedness are the emergency plans of the Federation and the *Länder* that are to be harmonised with each other. According to § 97 StrlSchG [1A-29b], these emergency plans are intended to enable all authorities and organisations involved in emergency response to take agreed decisions promptly in the event of an emergency and to take appropriate measures to protect the population in good time.

For this purpose, the Act contains detailed provisions for a general emergency plan of the Federation (§ 98, Appendix 5 StrlSchG). The task of the BMUB is to assess possible emergencies in Germany and abroad. On this basis, the general emergency plan of the Federation has to specify certain reference scenarios, which serve as a common basis for the planning of appropriate responses to these and other possible emergencies to the Federation and the *Länder*. This catalogue of scenarios will not only include severe NPP accidents in Germany or abroad but also emergencies in other nuclear facilities, transport accidents or the crash of a satellite with a radioactive source. For these emergencies, scenario-specifically optimised strategies for the protection of the population and the emergency workers are to be defined.

This general emergency plan is to be specified and supplemented by specific emergency plans of the Federation for certain administrative and economic areas (§ 99, Appendix 6 StrlSchG), e.g. by emergency plans for disaster control, for contaminated food and feed, for non-food products and the disposal of contaminated waste. In this respect, the Radiation Protection Act states that substances which occur in connection with emergency exposure situations and existing exposure situations are not to be regarded as "radioactive material" in legal terms. Furthermore, it is stated that substances and objects which are radioactively contaminated or can be contaminated outside a nuclear facility due to a nuclear accident or other radiological emergency are not "radioactive waste" within the meaning of the radiation protection law even if the owner discards or intends or is required to discard such substances or objects. Rather, they are classified as conventional "waste" which is principally to be disposed of under the general provisions of the Closed Substance Cycle and Waste Management Act [1B-13] and the other legal provisions of the Federation applicable to conventional waste. However, the special requirements of the Radiation Protection Act and the specific legal ordinances on the management of contaminated waste still to be enacted under the Radiation Protection Act must be observed.

The emergency plans of the Federation are adopted by the Federal Government as general administrative provisions, the regulations of which are binding for all authorities of the Federation and the *Länder* involved.

According to § 100 StrlSchG, the *Länder* also draw up general and specific emergency plans for all reference scenarios, which specify and supplement the plans of the Federation.

The authorities responsible for disaster control according to the law of the respective *Land* continue to provide off-site emergency plans for the vicinity of nuclear power plants and stationary nuclear facilities pursuant to § 101 StrlSchG in accordance with the legal provisions under *Land* law, insofar as emergencies in the facility may lead to serious impairment of health for a non-negligible number of persons in the vicinity of the facility. The off-site emergency plans are intended to supplement and concretise the planning contained in the general and specific emergency plans of the Federation and the *Länder*, and take into account the local conditions as well as the procedures and precautions of the radiation protection supervisors, being responsible for on-site emergency preparedness and response.

Through its approach that interlinks various areas, the new Radiation Protection Act integrates the legal and technical requirements of the Federation for radiological emergency protection into the

German federal system of civil protection. The authorities responsible for certain administrative and economic areas are also required to use their instruments to cope with radiological emergencies that have been tried and tested in everyday work or in coping with other crisis situations. The competent authorities decide which protective measures are appropriate in the event of an emergency in accordance with § 109 StrlSchG on the basis of the general legal provision applicable to such measures to avert danger. The Radiation Protection Act provides them with the radiological assessment criteria, previously not available in some areas, by the radiation protection principles to be observed (§ 92 StrlSchG), dose-related reference values for the protection of the population (§ 93 StrlSchG), statutory ordinances with dose and contamination values and regulations on the management of waste (§§ 94 – 96 StrlSchG) as well as the emergency plans (§§ 97 – 101 StrlSchG).

In the case of regional emergencies and beyond, only one picture of the radiological situation is relevant for all authorities of the Federation and the *Länder* to assess the radiological situation (§ 109(2) StrlSchG). For emergencies affecting more than one *Land*, this will be done by the radiological situation centre of the Federation, in case of regional emergencies generally by the respective *Land* (§ 108 StrlSchG). The radiological situation centre of the Federation will be established at the BMUB as a network consisting of the Federal Office for Radiation Protection (BfS), the Federal Office for the Safety of Nuclear Waste Management (BfE), the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH, as well as the Federal Office of Civil Protection and Disaster Assistance (BBK) (§ 106 StrlSchG). Other tasks of the radiological situation centre include the inter-ministerial coordination of protective measures and providing information to the public at the national and international level, as well as the preparation of protective action recommendations.

The protection of the emergency workers (§§ 113 – 117 StrlSchG) is improved, among other things, by staggered guide and reference values (20 – 100 – 250 – 500 mSv) which depend on the purpose of the respective application.

Furthermore, for the purpose of emergency preparedness and response, the Radiation Protection Act also contains regulations on information and protective action recommendations for the population (§§ 105, 112 StrlSchG), on the adaptation of the emergency plans to the evolving emergency situation (§ 111 StrlSchG) as well as on the management of exposure situations after an emergency in the long term (§§ 118 – 120, 152 StrlSchG) and takes over the regulations for the monitoring of environmental radioactivity from the superseded Precautionary Radiation Protection Act.

F.6 Article 26: Decommissioning

> ***Article 26: Decommissioning***
>
> *Each Contracting Party shall take the appropriate steps to ensure the safety of decommissioning of a nuclear facility.*
>
> *Such steps shall ensure that,*
>
> *i) qualified staff and adequate financial resources are available;*
>
> *ii) the provisions of Article 24 with respect to operational radiation protection, discharges and unplanned and uncontrolled releases are applied;*
>
> *iii) the provisions of Article 25 with respect to emergency preparedness are applied;*
>
> *iv) records of information important to decommissioning are kept.*

F.6.1 Basis

Introduction

The provisions relating to safety during the decommissioning of nuclear facilities are dealt with below in the overall context. The term "decommissioning" is used here within the meaning of the Joint Convention (Article 2) more broadly as a generic term for all decommissioning-related activities (including safe enclosure and dismantling as well as all measures leading to the release of a facility or a site from regulatory control). This corresponds to the technical and international usage. As understood in Germany, a nuclear facility will only be “under decommissioning” if a decommissioning licence has been granted.

Legal basis

With the entry into force of the Thirteenth Act Amending the Atomic Energy Act [1A-25] on 6 August 2011, the authorisation for power operation for the nuclear power plants Biblis Unit A and Unit B, Neckarwestheim I, Brunsbüttel, Isar 1, Unterweser, Philippsburg 1 and Krümmel expired. For the remaining eight nuclear power plants still in operation, the authorisation for power operation will expire successively between the end of 2017 and the end of 2022.

In Germany, the legal basis for licensing procedures for the decommissioning of nuclear facilities are the Atomic Energy Act (AtG) [1A-3] as well as the associated statutory ordinances and general administrative provisions. § 7(3) AtG contains the basic requirement for the licensing of decommissioning. Accordingly, the decommissioning of a facility licensed pursuant to § 7(1) AtG or dismantling of that facility or of parts thereof shall be subject to licensing. Here too, consideration of the state of the art in science and technology is retained as a guiding principle. In the future, safe enclosure will no longer be a decommissioning option for nuclear power plants in accordance with the amendments to the Atomic Energy Act resulting from the Act on the Reorganisation of Responsibility in Nuclear Waste Management.

The licensing procedure for the decommissioning of nuclear facilities is governed by the Ordinance Relating to the Procedure for the Licensing of Facilities (AtVfV) [1A-10]. It contains regulations pertaining to decommissioning, particularly with regard to third party involvement and the environmental impact assessment (EIA).

The requirements to be fulfilled for granting of a decommissioning licence are listed in § 7(2) AtG. They apply to the granting of a decommissioning licence according to § 7(3) mutatis mutandis as for the construction and operation of such a facility. The legislator placed the granting of a licence according to § 7(1) and (3) AtG under the reservation of § 7(2) AtG ("A licence may only be granted if" the requirements stated in § 7(2) AtG are fulfilled). This emphasises the particular weight that was given to construction and operation as well as to decommissioning, safe enclosure and dismantling of a nuclear facility by the legislator. Other licences regulated by the AtG (e.g. §§ 5 and 6 AtG) and by the Radiation Protection Ordinance (StrlSchV) [1A-8] (§§ 7 and 9) are not subject to such a reservation ("A licence shall be granted provided that" the licensing requirements are fulfilled).

Apart from the AtG, the StrlSchV is also relevant for dismantling since the technical and operational measures, procedures and precautions to prevent damage caused by ionising radiation are largely determined by it. These include the definition of the principles of radiation protection, the regulations on transport and transboundary movement of radioactive material, on clearance, on the qualification in radiation protection, on on-site organisation of radiation protection, on the protection of individuals in radiation protection areas, including the limitations of radiation exposure and preventive occupational medical care, on physical radiation protection, on the protection of the general public and the environment, on the protection against significant safety-related events, as well as on radioactive waste.

The licensed measures for decommissioning of nuclear facilities are monitored by supervisory controls.

Hazard potential of nuclear facilities during the decommissioning phase

The decommissioning phase of a nuclear facility is characterised by a gradual decrease in the radionuclide inventory of the facility, mainly by means of removal of the spent fuel and by decontamination and removal of contaminated and activated material as well as the final removal of any residual radionuclides and the release from nuclear regulatory control. Moreover, there are no energy potentials for the dispersion of the radioactive inventory since, contrary to the operational phase, the facility is cold and depressurised and since the major part of the residual radionuclides is bound in metal and concrete structures by activation. This is associated with a continuous decrease in the hazard potential as dismantling progresses. This fact is considered, among others, by specific decommissioning regulations mainly in the non-mandatory guidance instruments. This is to be taken into account by application of the existing regulatory framework or by revoking supervisory regulations and requirements during the licensing and supervision procedure which is adapted to the decreasing hazard potential.

Measures to ensure safety during decommissioning of nuclear facilities

The reporting on

- Article 18 (Implementing measures),
- Article 19 (Legislative and regulatory framework),
- Article 20 (Regulatory body),
- Article 21 (Responsibility of the licence holder),
- Article 22 (Human and financial resources),
- Article 23 (Quality assurance),
- Article 24 (Operational radiation protection), and
- Article 25 (Emergency preparedness)

also applies mutatis mutandis to the decommissioning of nuclear facilities. The presentations on the above-mentioned articles in this report relate in whole or in part also to the decommissioning of nuclear facilities. In principle, the same general safety requirements apply during decommissioning of a nuclear facility as during its operational phase, while in details there are some significant differences. For example, the possibility of criticality no longer exists for nuclear reactors once all spent fuel has been removed, and the amounts of activity discharged with waste water and exhaust air generally decrease. The safety requirements and their implementation are addressed in the reporting on Article 4.

In view of the fact that during the decommissioning of a nuclear facility it may become necessary to construct new facilities for the management of radioactive waste, Article 15 (Assessment of safety of facilities) of the Joint Convention is also relevant. The requirements of Article 15 on the assessment of the safety of facilities and their environmental impact prior to construction and commissioning likewise also apply to radioactive waste management facilities which are constructed when decommissioning nuclear facilities (see reporting on Article 15). Accordingly, the requirements of Article 16 (Operation of facilities) of the Joint Convention on the operation of radioactive waste management facilities also apply to the decommissioning phase by analogy (see the reporting on Article 16).

As a consensus between the Federation and the supervisory authorities of *Länder* on the most effective and harmonised approach to decommissioning procedures, on 23 June 2016, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) published an amended version of the Guide to the Decommissioning, the Safe Enclosure and the Dismantling of Facilities or Parts thereof as Defined in § 7 of the Atomic Energy Act – Decommissioning Guide) [3-73] in nuclear licensing and supervisory procedures. The aim of the Decommissioning Guide is

- to summarise the aspects relevant for licensing and supervision,
- to achieve a common understanding between the Federation and the *Länder* to ensure that decommissioning procedures are carried out appropriately, and
- to harmonise the existing views and procedures.

In particular, the Decommissioning Guide includes proposals for an appropriate procedure for decommissioning as well as the safe enclosure and the dismantling of nuclear facilities as defined in § 7 AtG in respect of the application of the non-mandatory guidance instruments, for the planning and preparation of decommissioning measures as well as for licensing and supervision.

It identifies the decommissioning-related provisions in the different documents of the legal framework and non-mandatory guidance instruments and describes their application. It also includes proposals for an appropriate procedure for the decommissioning of nuclear facilities and serves to harmonise the licensing procedures. For example, it is made clear that in connection with the decommissioning and dismantling of nuclear facilities, the work has to be organised in projects in accordance with the continuously decreasing hazard potential, and how in this context the regulations can be applied “analogously”, i.e. in the same way as to construction and operation. In all, the Decommissioning Guide thereby promotes the harmonisation of decommissioning procedures, but it does not represent a directive or administrative provision.

As a technically oriented supplement to the Decommissioning Guide, on 16 March 2015, the Nuclear Waste Management Commission (ESK) adopted the Guidelines for the decommissioning of nuclear facilities [4-4]. In these Guidelines, the ESK summarises those technical requirements which it considers necessary to be observed by the operators of nuclear facilities in order to ensure safety in connection with decommissioning. These requirements relate above all to the preparation and execution of decommissioning; some requirements, however, are also directed at the construction and operation of a nuclear facility as they are highly relevant for the later decommissioning. The Guidelines for decommissioning are not legally binding for any third parties. They rather form the basis for the ESK's assessments when discussing concrete decommissioning procedures. Hence the Guidelines contribute to the state of the art in science and technology of the German nuclear non-mandatory guidance instruments and thereby to a high level of safety of decommissioning of nuclear facilities.

Previously, the nuclear rules and regulations had treated the two decommissioning options of direct dismantling and deferred dismantling after safe enclosure as equivalent options. In the future, nuclear power plants will have to be shut down and dismantled immediately in accordance with the amendments pursuant to § 7(3) AtG. In the case of safe enclosure, transfer of knowledge of staff with operating experience to staff for deferred dismantling must be ensured by documentation and retention of relevant information. The decommissioning licence has to specify kind and scope of the safety reviews for the facility to be conducted during safe enclosure at regular intervals (at least every ten years).

F.6.2 Availability of qualified staff and adequate financial resources

The experience gained from various decommissioning projects of nuclear facilities in Germany has shown that the operating staff's knowledge of the facility is very valuable for the safe and efficient execution of decommissioning. For this reason, the operators involve the operating staff also in the decommissioning phase.

The manner in which the availability of financial resources is secured for the decommissioning phase of a nuclear facility differs between publicly-owned facilities and facilities belonging to the private electric power utilities:

- The decommissioning of publicly-owned facilities is financed from the current budget. For most projects (see Table F-4), the Federation covers the bulk of the costs. Financing includes all expenses incurred for the remaining operating life, spent fuel management, execution of the licensing procedure, dismantling of facility components, and disposal of the radioactive waste (including all preparatory steps).
- The financial resources for facilities belonging to the privately-owned electric power utilities, in particular nuclear power plants are provided in the form of provisions built up during the operational phase, based on an accumulation period of 25 years. The formation of provision according to commercial law is based on the waste management obligation under public law, which is derived from the AtG. The existence of provisions for decommissioning shall guarantee that financial resources will be available for decommissioning and dismantling after final cessation of electricity production and there are no more revenues from electricity charges. By the expensed formation of provisions during the operational phase of the nuclear power plant, the funds are accumulated, thus preventing the contributions from being distributed as profits to the shareholders. The electric power utilities transferred the funds for storage and disposal, which follow the waste management steps of decommissioning, dismantling of the nuclear power plants and the proper packaging of the spent fuel and the radioactive waste, to a public-law fund by 1 July 2017, the deadline for payment laid down by law, in accordance with their payment obligations pursuant to the Act on the Reorganisation of Responsibility in Nuclear Waste Management (see Chapter E.2.2 and Chapter F.2.2).
- Decommissioning is carried out by the electric power utilities on their own responsibility under the supervision of the competent authorities. The extent of the provisions for the decommissioning of nuclear power plants covers all costs related to the dismantling of the power plant. These are the costs of the so-called post-operational phase during which the

power plant is transferred into a state in which it can be dismantled after final cessation of power operation, the costs for licensing and supervisory procedures, as well as the costs for the dismantling. The total amount of costs is estimated based on basic studies which are regularly updated by an independent expert with due regard for technical advancements and general price trends. Information on the provisions are provided to the Federal Office for Economic Affairs and Export Control (BAFA) by the electric power utilities once a year (see Chapter E.2.2 and Chapter F.2.2).

- The above statements apply to the commercial facilities of the nuclear fuel cycle and for waste management analogously. However, these facilities are not covered by the new provisions of the Act on the Reorganisation of Responsibility in Nuclear Waste Management, so that the provisions to be formed for this purpose must continue to also cover storage and disposal of the waste.

Table F-4: Research institutions and dismantling installations for research facilities in which nuclear facilities are operated or decommissioned and dismantled and which are financed from public funds

Research institution	Short description	Funding
Kerntechnische Entsorgung Karlsruhe GmbH (KTE), formerly Wiederaufar-beitungs-anlage Karlsruhe Rückbau- und Entsorgungs-GmbH (WAK GmbH)	Founded in 2006 as Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH (WAK GmbH) as part of the takeover of the Karlsruhe reprocessing plant by the publicly owned EWN. At the same time, the company's spectrum of tasks was extended to the operation and dismantling of the Karlsruhe vitrification plant (VEK). In mid-2009, the old nuclear facilities FR-2, KNK II and MZFR as well as the conditioning facilities for radioactive waste of the Central Decontamination Department of the KTE GmbH (HDB) of the former Karlsruhe research centre (FZK, now Karlsruhe Institute of Technology, KIT) were separated and transferred to the WAK GmbH. In 2017, the WAK GmbH was renamed in Kerntechnische Entsorgung Karlsruhe GmbH (KTE). Since then, the latter has been continuing the decommissioning of the research facilities and the operation of HDB. Whenever other nuclear research facilities are taken out of operation by KIT, their dismantling will be handled by the KTE.	Federation (mainly), *Land* of Baden-Wuerttemberg
Jülicher Entsorgungs-gesellschaft für Nuklearanlagen mbH (JEN)	With effect from 30 September 2015, the nuclear service of Forschungszentrum Jülich GmbH (FZJ) was separated from the FZJ and merged with the AVR GmbH located at the site to form the Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH. Since then, the JEN has been continuing the decommissioning of the research facilities (FRJ-2, AVR, GHZ, CZ) as well as the operation of the waste treatment and conditioning facilities and storage facilities. After shutdown of further nuclear research facilities by FZJ, they will be dismantled by the JEN mbH.	Federation (mainly), *Land* of North Rhine-Westphalia
Helmholtz-Zentrum Geesthacht – Zentrum für Material- und Küstenforschung GmbH (formerly For-schungszentrum Geesthacht (GKSS))	Founded in 1956 as Gesellschaft für Kernenergieverwertung in Schiffbau und Schiffahrt (company for exploitation of nuclear energy in shipbuilding and navigation), operation of the nuclear ship “Otto Hahn”. Current research topics in the fields of traffic and energy technology, process and biomedical technology, water and climate in coastal regions. Decommissioning of the research reactors FRG-1 and FRG-2, storage of the ship reactor, and management of radioactive waste from the nuclear ship Otto Hahn.	Federation, *Länder* of Schleswig-Holstein, Lower Saxony, Hamburg, Bremen

Research institution	Short description	Funding
Helmholtz Zentrum München, Neuherberg	Founded in 1964 as Gesellschaft für Strahlenforschung (GSF) (company for radiation research) for the construction and operation of radiation research facilities and carrying out research into the underground storage of radioactive waste; safe enclosure of the research reactor FRN; current research topics in environmental and health research. With effect from 1 January 2008, the GSF was renamed Helmholtz Zentrum München – Deutsches Forschungszentrum für Gesundheit und Umwelt GmbH.	Federation (mainly), Free State of Bavaria
Helmholtz-Zentrum Berlin	Founded in 2008 by merging the Hahn-Meitner-Institut Berlin and the Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung (BESSY); current research topics in the areas structural research, material sciences etc.; operation of the research reactor BER II	Federation (mainly), *Land* of Berlin
Strahlenschutz, Analytik und Entsorgung Rossendorf e.V. (VKTA), Dresden	Founded in 1992. VKTA carries out the decommissioning of the nuclear facilities of the former Central Institute of Nuclear Research of the former German Democratic Republic (GDR). These are the RFR research reactor and the AMOR facilities for fission molybdenum production. The zero-power reactors RRR and RAKE have already been dismantled and fully removed.	Free State of Saxony
Technische Universität München	Operation of the FRM II, decommissioning and dismantling	Free State of Bavaria (mainly), Federation
Various universities	Operation/decommissioning of smaller research reactors	Federation, respective *Länder*
Kerntechnische Entsorgung Karlsruhe GmbH (KTE), formerly Wiederaufar-beitungs-anlage Karlsruhe Rückbau- und Entsorgungs-GmbH (WAK GmbH)	Founded in 2006 as Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH (WAK GmbH) as part of the takeover of the Karlsruhe reprocessing plant by the publicly owned EWN. At the same time, the company's spectrum of tasks was extended to the operation and dismantling of the Karlsruhe vitrification plant (VEK). In mid-2009, the old nuclear facilities FR-2, KNK II and MZFR as well as the conditioning facilities for radioactive waste of the Central Decontamination Department of the KTE GmbH (HDB) of the former Karlsruhe research centre (FZK, now Karlsruhe Institute of Technology, KIT) were separated and transferred to the WAK GmbH. In 2017, the WAK GmbH was renamed in Kerntechnische Entsorgung Karlsruhe GmbH (KTE). Since then, the latter has been continuing the decommissioning of the research facilities and the operation of HDB. Whenever other nuclear research facilities are taken out of operation by KIT, their dismantling will be handled by the KTE.	Federation (mainly), *Land* of Baden-Wuerttemberg

In all cases, staff costs are fully included in the financing, which in some cases account for 50 % of the total costs and more. Analogous to the operating phase, it is thus ensured that qualified staff is also available to the extent required during decommissioning. The high level of education and qualification in Germany is maintained through courses for achieving and maintaining the required technical qualification, education and training courses, as well as research and teaching at universities and technical colleges. Significant progress has been made in this area in recent years, as summarised in Chapter F.2.1.

F.6.3 Radiation protection during decommissioning

The requirements regarding radiation protection of a nuclear facility which is in the process of decommissioning fully correspond to those applicable during operation. Details can be found in the reporting on Article 24 (Operational radiation protection) of the Joint Convention.

F.6.4 Emergency preparedness

The extent of the measures for emergency preparedness during decommissioning of a nuclear facility is adapted in line with the hazard potential posed by the facility. Essentially, however, such measures do not differ from the measures for emergency preparedness during operation (see reporting on Article 25).

F.6.5 Keeping of records

Keeping of records of information important for decommissioning concerns, on the one hand, records relating to the construction and operation of the nuclear facility which will need to be accessed later in the decommissioning phase and, on the other hand, to records generated during decommissioning and which are relevant for the long-term documentation of decommissioning itself. In the following, these two issues are dealt with separately.

Keeping of records of information pertaining to construction and operation

Records of information and documentation relating to the construction and operation of nuclear power plants are regulated in nuclear safety standard KTA 1404 "Documentation during the Construction and Operation of Nuclear Power Plants" (see Safety Standards of the Nuclear Safety Standards Commission (KTA) in Annex L-(d)). The need for keeping all relevant documentations available is derived from Criterion 2.1 of the Safety Criteria for Nuclear Power Plants [3-0-1], which stipulates that all documentation necessary for quality assessment must be kept available. This requirement is specified in nuclear safety standard KTA 1404, according to which the following applies:

> "The documentation in nuclear power plants comprises all documents which serve as certificates in the licensing and supervisory procedure as well as all organisational regulations that are the basis for the safe operation.
>
> The purpose and function of the documentation are, among others,
>
> a) proving the existence of or compliance with statutory prerequisites (e.g. licensing prerequisites in accordance with § 7(2) AtG),
>
> b) describing the required condition of the facility and the essential processes during its construction,
>
> c) enabling an assessment of the actual condition of the facility,
>
> d) presenting the circumstances and provisions required for a safe operation of the facility,
>
> e) enabling the feedback of experience, and
>
> f) providing a knowledge base for ageing management."

These records also include the documentation of operation. In addition, KTA 1404 stipulates the following with respect to the completeness of documentation and the updating thereof:

> "With respect to the information contained, the documentation shall be complete, explicit and unambiguous.
>
> The documentation shall describe both the required state and the actual state of the power plant and its parts and of the organisation.
>
> The licence applicant or licensee shall be responsible for creating, maintaining, updating and archiving the documentation."

This means that not only the state of the facility at the start of operation must be fully documented but that this documentation must also be adapted to all changes and must reflect the actual state of the facility at all times. This ensures that all relevant information from the operating phase is available when required for the decommissioning phase. KTA 1404 further specifies that the documentation must be safely kept at a place and in a form suitable for extended storage, and that a secondary set of documents must be retained at a place where it is not endangered by any impact that may originate from the facility. According to the Decommissioning Guide [3-73], keeping of a duplicate documentation is only required until removal of the spent fuel. The period for which records have to be kept depends on the type of documents and ranges from 1 to 30 years.

These requirements also apply mutatis mutandis to other types of nuclear facilities within the scope of application of the Joint Convention. Within the context of nuclear regulatory supervision, the competent authority satisfies itself that the records have been duly updated and correctly filed.

Keeping of records of information from the decommissioning phase

As for the operating phase, information from the decommissioning phase which have to be kept for longer periods of time cover a number of topics, such as operation, surveillance and radiation protection, in particular,

- shift logs including shift handover protocols,
- protocols of surveillance and measurements of activity discharges,
- reports on incidents and abnormal events as well as the chosen countermeasures,
- record keeping on measurements of individual doses and body doses,
- record keeping on production, acquisition, transfer and other dispositions of radioactive substances,
- protocols of contamination measurements according to § 44 of the Radiation Protection Ordinance (StrlSchV) in cases where limits were exceeded.

Record keeping on production, acquisition, transfer and other dispositions of radioactive substances and on cleared materials, which is regulated in § 70 StrlSchV [1A-8] is of particular relevance for the decommissioning phase. § 70(6) requires that such records must be kept for 30 years from the date when the material referred to is removed from the facility or when the clearance procedure has been completed. Records and documentation must be deposited with the competent authority at the request of the latter.

§ 70(6) StrlSchV further requires that the records and documentation must be deposited at a place designated by the competent authority without delay if activity ceases prior to the end of the prescribed period. This ensures that the relevant documentation is still kept for the required period even if the operator of a nuclear facility no longer exists.

According to the Decommissioning Guide [3-73], the operator should prepare a final decommissioning report after completion of all decommissioning work and keep it together with the documentation.

G Safety of spent fuel management

This section deals with the obligations under Articles 4 to 10 of the Convention.

Developments since the Fifth Review Meeting:

In its final report [KOM 16], the Commission on Storage of High-Level Radioactive Waste published proposals for the decision bases with regard to the new site selection and corresponding recommendations for the action of the *Bundestag* and the *Bundesrat*. Based on the Commissions' results, the organisational structure in the field of radioactive waste disposal was realigned. Furthermore, the Act Amending the Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste and for the Amendment of Other Laws [1A-7b] largely entered into force on 16 May 2017. It includes, inter alia, two empowerments for issuing statutory ordinances on the introduction of safety requirements and requirements for the conduct of the preliminary safety analyses in terms of disposal.

In December 2015, the Nuclear Waste Management Commission (ESK) adopted the Guideline on the safe operation of a disposal facility for in particular heat-generating radioactive waste [4-17]. This guideline serves to specify the "Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste" as at 30 September 2010 published by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU, now Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)). The requirements for waste packages for disposal of heat-generating radioactive waste with due regard to the waste contained formulated in the Safety Requirements are further concretised in the ESK recommendation of March 2016 [4-18].

In its statement of May 2016 [4-19], the ESK deals with the question which research projects must be initiated for the purpose of identification and assessment of the alternative host rock with regard to their suitability as a disposal medium.

In October 2015, the ESK adopted a discussion paper on the extended storage of spent fuel and other heat-generating radioactive waste [4-20] discussing the storage beyond the licensed period of 40 years.

G.1 Article 4: General safety requirements

Article 4: General safety requirements

Each Contracting Party shall take appropriate steps to ensure that all stages of spent fuel management, individuals, society and the environment are adequately protected against radiological hazards.

In so doing, each Contracting Party shall take appropriate steps to

i) ensure that criticality and removal of residual heat generated during spent fuel management are adequately addressed;

ii) ensure that the generation of radioactive waste associated with spent fuel management is kept to the minimum practicable, consistent with the type of fuel cycle policy adopted;

iii) take into account interdependencies among the different steps in spent fuel

> *management;*
>
> *iv) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards;*
>
> *v) take into account the biological, chemical and other hazards that may be associated with spent fuel management;*
>
> *vi) strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation;*
>
> *vii) aim to avoid imposing undue burdens on future generations.*

G.1.1 Basis

The fundamental concepts of precaution regarding spent fuel management are laid down in the Atomic Energy Act (AtG) [1A-3] and the Radiation Protection Ordinance (StrlSchV) [1A-8]. According to these concepts, any unnecessary radiation exposure or contamination of persons and the environment is to be prevented, and, with due regard for the state of the art in science and technology and the particular circumstances of each individual case, is to be kept as low as practicable even where the values are below the authorised limits (§ 6 StrlSchV).

The planning of structural or technical measures to protect against design basis accidents is based on the dose limits for the environment (§§ 49 and 50 StrlSchV) or is applied mutatis mutandis.

The following principles for spent fuel management are derived from the precautionary concept:

- fundamental protection goals on radioactivity confinement, removal of decay heat power, subcriticality, avoidance of unnecessary radiation exposure,
- requirements regarding shielding, design and quality assurance, safe operation, storage and safe dispatch of radioactive substances.

For the purpose of protection against the hazards emanating from radioactive substances and control of their use, the AtG requires that the construction, operation and decommissioning of nuclear facilities is subject to regulatory licensing (see reporting on Article 19).

Additional requirements regulate liability in case of damages [1A-11], protection against disruptive actions or other interference by third parties [3-62], [BMU 13b] and the control of fissile material according to international conventions [1F-14] (see reporting on Article 24 or Article 27).

G.1.2 Assurance of subcriticality and residual heat removal

Measures are taken to address the derived fundamental protection goals of reliable maintenance of subcriticality and safe removal of decay heat. Particularly regarding the dry storage of spent fuel from light water reactors (LWR), high temperature reactors (HTR), experimental and demonstration as well as research reactors, these measures are specified in greater detail by the Guidelines for dry cask storage of spent fuel and heat-generating waste [4-2] of the Nuclear Waste Management Commission (ESK). With regard to criticality safety in connection with the wet storage of spent fuel, KTA 3602 is applied, whilst KTA 3303 is applied with regard to the removal of decay heat (see Safety Standards of the Nuclear Safety Standards Commission (KTA) in Annex L-(d)). The DIN standard "Criticality safety taking into account the burn-up of fuel for transport and storage of irradiated light water reactor fuel assemblies in casks" available since 2007 and last updated in 2015 [DIN 25712] is to be applied for demonstrating criticality safety.

The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU, now Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)) has submitted “Safety Requirements Governing the Final Disposal of Heat-Generating Waste” [BMU 10] which were published on 30 September 2010. It stipulates, among other things, that subcriticality is to be demonstrated and that inadmissible influences on the effect of the geological barrier by the temperature development of the waste are to be excluded. In a statement of March 2016, the ESK formulated requirements for waste packages for the disposal of heat-generating radioactive waste [4-18] where the BMU safety requirements of 2010 [BMU 10] are defined in a more detailed way. Furthermore, in a recommendation of December 2015, the ESK published the Guideline on the safe operation of a disposal facility for in particular heat-generating radioactive waste [4-17] on the demonstration of maintenance of subcriticality and safe removal of decay heat power as safety-related boundary conditions.

The Act Amending the Repository Site Selection Act (StandAG) [1A-7b], which entered into force in May 2017, includes two empowerments for issuing statutory ordinances on the introduction of safety requirements and requirements for the conduct of the preliminary safety analyses in terms of disposal. These ordinances will replace the BMU Safety Requirements of 2010 [BMU 10].

G.1.3 Limitation of radioactive waste generation

§ 6(1) and (2) StrlSchV [1A-8] requires that any unnecessary radiation exposure or contamination of persons and the environment shall be prevented, and, taking due account of the state of the art in science and technology and the particular circumstances of each individual case, radiation exposure or contamination shall be kept as low as practicable, even where the values are below the authorised limits. Based on this, and analogous to § 23 of the Closed Substance Cycle and Waste Management Act [1B-13], the requirement to keep the generation of radioactive waste associated with spent fuel management to the minimum practicable is derived. Due to optimised strategies for nuclear fuel appliance, the accumulation of spent fuel has decreased.

The § 2d AtG [1A-3] implies an imperative to limit the accumulation of radioactive waste. Moreover, private operators of nuclear facilities in the Federal Republic of Germany in any case have a vested interest in limiting waste volumes for economic reasons. The operators are and will be responsible for the management and funding of the conditioning and proper packaging of radioactive waste.

G.1.4 Taking into account interdependencies between the different steps in spent fuel management

According to § 9a AtG [1A-3] it is necessary to prove to the supervisory authority that adequate provisions exist for the non-hazardous reuse or controlled disposal of spent fuel. For this purpose, realistic plans are submitted annually showing that sufficient storage capacity remains available for those spent fuel already existing and those expected to arise in future, and that sufficient and adequate storage facilities are legally and technically available to meet concrete requirements for the next two years. Furthermore, similarly structured proof is also furnished to the supervisory authorities regarding the storage of returned waste from the reprocessing of spent fuel in foreign countries, as well as for the reuse of the separated plutonium from the reprocessing of spent fuel in nuclear power plants, and for the whereabouts of the separated uranium from the reprocessing of spent fuel.

The type of conditioning (processing and packaging) depends on the specifications and requirements of the acceptance criteria laid down in the licence for the planned storage facility or disposal facility.

Quantitative information showing the consideration of the reciprocal dependence can be found in the comments on Article 32(2).

G.1.5 Application of suitable protective methods

The AtG and the StrlSchV require that precautions must be taken against potential damages in keeping with the state of the art in science and technology to guarantee effective protection. For compliance with the state of the art in science and technology on spent fuel management, internationally accepted criteria and standards of the International Atomic Energy Agency (IAEA) ([IAEA 12a] and [IAEA 02]), the International Commission on Radiological protection (ICRP) and Council Directive 2013/59/EURATOM [1F-24] are also referred to. This is ensured by the nuclear licensing applicable to the corresponding nuclear facility (see reporting on Article 19).

Compliance with the provisions of nuclear licensing is ensured by the supervision of the competent authorities of the Federation and the *Länder* (see reporting on Article 32(2)).

G.1.6 Taking into account biological, chemical and other hazards

The provisions of other legal fields take into account the precautions against damage from biological, chemical and other hazards (see reporting on Article 19). Regarding disposal, which is predominantly affected in Germany, chemical and other hazards are considered within the framework of the plan approval procedure by corresponding safety analyses.

In addition, the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10] stipulates the performance of an environmental impact assessment for the construction of facilities and compliance with other licensing requirements (e.g. for non-radioactive emissions and discharges into waters).

G.1.7 Avoidance of impacts on future generations

The Act Amending the StandAG [1A-7b] and the following site selection procedure specify the individual procedural steps for the open-ended and unbiased search for and selection of a site for the safe disposal of heat-generating radioactive waste with the aim of establishing a disposal facility that meets the high requirements for the long-term protection of man and the environment against the hazards of radioactive waste. Thus, the Federation and the *Länder* fulfil their responsibility for the long-term protection of man and the environment against the hazards of radioactive waste also with regard to future generations.

Safety criteria for the emplacement of radioactive waste in a mine entered into force in Germany in 1983 [3-13]. On the basis of the safety criteria, safety requirements of the BMU [BMU 10] were established for a repository for heat-generating radioactive waste not yet implemented. These consider the national and international developments, recommendations of the ICRP and OECD/NEA, the standards of the European Communities, and the safety principles of the IAEA on radioactive waste management [IAEA 06].

As things stand, the impacts of discharges of radionuclides from the repository operation in Germany must not exceed the dose limits applicable to nuclear power plants today. As regards the post-closure phase of a future repository for heat-generating radioactive waste, the safety requirements of the BMU [BMU 10] apply. These postulate the integrity of the rock surrounding the repository as well as an optimisation of the repository. Furthermore, limits are given for the admissible individual effective dose. For probable developments, the reference level is 10 µSv/a, for less probable developments 100 µSv/a. Furthermore, in its final report [KOM 16], the Commission on the Storage of High-Level Radioactive Waste formulated recommendations for casks for disposal. Accordingly, a cask is to perform a protective function during operation and emplaced in a retrievable manner. For the post-closure phase, the possibility of recovery of the casks for 500 years is to be provided for. Requirements for casks will be specified by an ordinance on safety requirements for disposal which is to be drawn up.

G.1.8 Avoidance of undue burdens on future generations

The safety criteria for the emplacement of radioactive waste in a mine [3-13] as well as the Safety Requirements Governing the Final Disposal of Heat-Generating Waste [BMU 10] already make allowance for Principle 7 of the IAEA Fundamental Safety Principles [IAEA 06]. They ensure that no undue burdens are imposed on future generations.

Financial resources for decommissioning and dismantling, as well as for the proper conditioning including packaging of the radioactive waste will continue to be set aside by the operators of the nuclear power plants on the basis of commercial law, whereas, the Federation will assume responsibility for the management and financing of storage and disposal on the basis of the Act on the Reorganisation of Responsibility in Nuclear Waste Management [1A-31]. The financial means required for it were made available to the Federation by the operators as at 1 July 2017 and transferred to a fund for the financing of nuclear waste management. After closure of a repository, monitoring and maintenance measures, apart from minimal evidence and control measures, are not necessary. For this reason, no unreasonable costs are incurred after closure that would have to be borne by future generations.

G.2 Article 5: Existing facilities

> ***Article 5: Existing facilities***
>
> *Each Contracting Party shall take the appropriate steps to review the safety of any spent fuel management facility existing at the time the Convention enters into force for that Contracting Party and to ensure that, if necessary, all reasonably practicable improvements are made to upgrade the safety of such a facility.*

G.2.1 Fulfilment of the obligations under the Convention regarding existing facilities

The fundamental requirements governing the preventive action to be taken are set forth in the Atomic Energy Act (AtG) [1A-3], the Radiation Protection Ordinance (StrlSchV) [1A-8] and other legal provisions, as well as in non-mandatory guidance instruments (see reporting on Articles 18 to 20) which satisfy, and in some cases exceed, all the requirements of the Joint Convention. An explicit review of the facilities to verify compliance with the requirements of the Joint Convention is therefore not felt to be necessary.

Furthermore, existing facilities are also subject to continuous regulatory control throughout their entire operational life. Whenever there are any advancements in the state of the art in science and technology, the regulatory body may insist on a corresponding upgrade in safety in accordance with the provisions of § 19 AtG.

Independently from this, the regulatory framework governing the safe management of spent fuel [4-2] stipulates regular reviews intended to ensure the compliance with the protection goals stipulated in the Act in line with the latest state of the art in science and technology. The protection goals encompass the protection of the general public in the vicinity of the facility, the protection of the environment and the protection of operating personnel, as well as the protection of property against the effects of ionising radiation.

G.2.2 Extended storage of spent fuel

The dry storage of spent fuel and high level vitrified waste in casks is already being practiced for decades in Germany. The licences for the storage of spent fuel and heat-generating waste are limited to 40 years. Table D-1 shows, when the licence of the respective storage facility expires. Spent fuel storage is necessary until the transportation to the repository for heat-generating radioactive waste is possible; according to the Act Amending the Repository Site Selection Act (StandAG) [1A-7b], the site selection process began anew. Based on the current knowledge, it cannot be ensured that all fuel will be removed from the storage facilities during the licensed period of 40 years.

According to the National Programme (NaPro) for waste management [BMUB 15], the waste is to be stored at the existing storage facility sites until the receiving storage facility at the future repository site for heat-generating radioactive waste is ready to accommodate the respective casks. According to the NaPro, the commissioning of the disposal facility around the year 2050 has been taken as a basis, which means that the licensed storage periods will not be sufficient (see Table D-1). The periods necessary for storage are currently the subject of discussions. The Nuclear Waste Management Commission (ESK) has published a discussion paper [4-20] where they expect storage periods of up to 100 years. The Commission on the Storage of High-Level Radioactive Waste, too, expects an extension of the storage period, which they have been pointing out, is absolutely essential. In its final report [KOM 16], the Commission describes the interdependence of the storage period and the disposal facility available. The storage period is to be limited to the strictly necessary period, but the period until the commissioning of a disposal facility for high level radioactive waste may only be partially shortened with required due diligence, in order to allow a comprehensive participation of the general public during the entire process. An extension of the storage period is subject to licensing. According to § 6(5) AtG [1A-3], licences for storage facilities may only be renewed on imperative grounds and after prior referral to German *Bundestag*.

In its discussion paper on the extended storage of 2015 [4-20], the ESK states that the operating experience gained and the safety reviews performed did not identify any deterioration of the safety functions. But furthermore, safety analyses on the basis of reliable data will have to be provided for an extension of the storage licence. Dealing with relevant issues on the extended storage at an early stage, enables competent assessment of the required measures for the future.

The necessary maintenance of know-how over the required period will become more important in the medium term, also with a view to the increasing independency of the storage facilities due to the dismantling of nuclear power plants.

Moreover, in the ESK paper of 2015, the storage is not considered to be a single, independent step, but only a partial step of the entire waste management process; this is because there is interdependency between storage and other waste management steps (conditioning and disposal) as well as transportation. Thus, an overall view and a better coordination of the different waste management steps are recommended which, under the nuclear law, are considered to be legal individual processes and, in addition, are affecting the transport law. Thus, the development and implementation of independent standards is proposed for the extended storage which should also present alternatives for the permanent maintenance of type approvals under traffic law until the end of the extended storage. According to ESK, it is necessary to establish clearly defined responsibilities with an appropriate coordinating structure for the implementation of the overall waste management system.

In the German rules and regulations, requirements for storage are laid down in the Guidelines for dry cask storage of spent fuel and heat-generating waste [4-2] of 2013 of the ESK. The guidelines refer to a temporary storage for a period applied for in the licensing procedure. The limitation in time of the storage licences for German storage facilities is not based on limiting parameters of physical-technical nature.

Furthermore, the Periodic Safety Review (PSR) of storage facilities is laid down in the AtG. According to § 19a(3) AtG [1A-3], anyone who operates a facility (according to § 2(3a)(1) AtG) is required after the start of operations (emplacement of the first cask) to conduct and to evaluate every ten years a safety review of the facility and to improve on this basis the safety of the facility continuously. The results of the safety review and evaluation shall be submitted to the supervisory authority.

Requirements for the performance of PSR were published by the ESK as ESK guidelines for performance of periodic safety review and on technical ageing management for storage facilities for spent fuel and heat-generating radioactive waste in March 2014 [4-5a].

The key objectives of the PSR are as follows:

1. summarised documentation and evaluation of all events and insights with regard to the safety level and operating reliability as well as the minimisation of the radiation exposure gathered in the review period,
2. update of the safety assessment of the actual condition of the storage facility on the basis of the licences issued and the necessary precautions to be taken according to the state of the art in science and technology to prevent damage resulting from the storage of nuclear fuel with regard to:
   - the safe and reliable continued operation of the storage facility,
   - an effective and reliable accident management,
   - the impacts of ageing mechanisms on the condition of the storage facility and its installations, and on the transport and storage casks, and
   - the safe handling and later removal of the transport and storage casks,
3. derivation of findings and measures for further operation.

The operator of the storage facility is responsible for the conduction of the PSR. The results and the measures derived are to record and to submit to the supervisory authority. If required, the supervisory authority defines necessary measures for the operation of the reviewed storage facility and supervises the proper realisation at due date. The nuclear licensing authority, since July 2016 the Federal Office for the Safety of Nuclear Waste Management (BfE), takes notice of the results of the PSR of the storage facility as well as of the assessment by the supervisory authority and – if necessary – can derive updated or additional requirements for ongoing or future licensing procedures.

In addition to the requirements for the PSR, requirements for the technical ageing management were specified in the ESK guideline [4-5a] of 2014. The objective of these is to identify and monitor safety-relevant damage mechanisms and to control them by appropriate measures. The guideline refers to the accessible technical equipment and components relevant for the compliance with the protection goals. It is especially the exchange of experience between the facility operators which should serve the purpose of the further development of the ageing management. Non-technical aspects such as knowledge management, data protection, personnel planning and protection of the necessary resources that may reach the safety-relevant level due to long-term changes of the storage operation are not yet or only with general requirements laid down in the German rules and regulations. According to the International Atomic Energy Agency (IAEA), these issues belong to safety management.

On the one hand, findings from operational experience and inspections gathered from the PSR shall be taken as a basis for an extension of storage, and on the other hand, sufficiently reliable safety-relevant data and materials are required. For this purpose, data transferable to Germany and corresponding findings from international research programmes can be used, or additional national research studies may be conducted in a targeted manner [4-20]. As the highest supervisory authority, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) fosters the national research in this field and supports a participation/cooperation of expert organisations that participate on its behalf in international organisations like IAEA and OECD/NEA and take up new aspects on storage or exchange experiences. A result thereof is an approach to the identification of safety-related knowledge gaps with regard to the extended storage period. To date, aspects like the state of the dry storage in Germany and in international comparison, technical and non-technical ageing management, the long-term behaviour of casks and inventories and problems relating to storage in Germany, and the subject of experience exchange were covered within the national research programmes. Furthermore, some long-term tests have already been initiated; but according to the current state of the art in science and technology, no final statements can yet be made as the data gathered from experimental studies is not yet sufficient and reliable comparative data obtained from real operation is not freely available. The issue of extended storage and the safety-related aspects were taken up in relevant research programmes.

A major focus of the Federal Ministry for Economic Affairs and Energy (BMWi's) project funding on site-independent waste management research is the investigation of the effects of extended storage periods on waste and casks. The BMWi thus promotes the creation and continuous development of scientific bases for the assessment of the long-term behaviour of casks and waste under storage-specific loading conditions and during the subsequent transports prior to disposal. This will contribute to increasing safety during extended storage and subsequent transports as well as to the enhancement of the state of knowledge about the condition of waste and containers prior to disposal. The focus is on the investigation of ageing effects and damage mechanisms as well as the provision of appropriately adapted analysis and evaluation methods. Research and development activities on the provision of methods for continuous condition monitoring are also promoted. In addition, work on dealing with damaged fuel assemblies, reconditioning of waste or contributions to the further development of ageing management can also be sponsored.

G.3 Article 6: Siting of proposed facilities

> ***Article 6: Siting of proposed facilities***
>
> *(1) Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed spent fuel management facility,*
>
> *i) to evaluate all relevant site-related factors likely to affect the safety of such a facility during its time of operation;*
>
> *ii) to evaluate the likely safety impact of such a facility on individuals, society and the environment;*
>
> *iii) to make information on the safety of such a facility available to members of the public;*
>
> *iv) to consult Contracting Parties in the vicinity of such a facility, insofar as they are likely to be affected by that facility, and provide them, upon their request, with general data relating to the facility to enable them to evaluate the likely safety impact of the facility upon their territory.*
>
> *(2) In so doing, each Contracting Party shall take the appropriate steps to ensure that such faculties shall not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 4.*

G.3.1 Taking into account site-related factors affecting safety during the operating lifetime

§ 7(1) of the Atomic Energy Act (AtG) [1A-3] regulates the licensing of stationary installations for the management of spent fuel, whilst the licensing of the storage of nuclear fuel outside Government custody is regulated in § 6(1) AtG. The definition in the AtG encompasses storage of spent fuel. In order to obtain such a licence, the applicant must submit documentation containing all the relevant data required for the purposes of assessment. This data is summarised in the safety report, a key document in the licensing procedure. The nature and scope of documentation and the data it contains are regulated in the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10].

§ 2 AtVfV prescribes that the licence application for the planned construction of a new facility must be submitted in writing to the licensing authority. This application must also contain data pertaining to all relevant site-related factors.

§ 3 AtVfV specifies the nature and scope of documentation referred to in greater detail in the remarks on Article 19(2)(ii) in Chapter E.2.3. Usually, the required information pertaining to the site and the installation is compiled in the safety report and supporting documents.

An Environmental Impact Assessment (EIA) is required for facilities which are listed in Appendix 1 of the Environmental Impact Assessment Act (UVPG) [1B-14]. According to numbers 11.1 and 11.3 of Appendix 1 of the UVPG, an environmental impact assessment is required for the construction and operation of facilities for the treatment of spent fuel, as follows:

11.1 Construction and operation of a stationary installation for the production, treatment, processing or fission of nuclear fuel or the reprocessing of irradiated nuclear fuel, 11.3 Construction and operation of a facility or installation for the treatment or processing of irradiated nuclear fuel or highly radioactive waste or for the sole purpose of storage of irradiated fuel or radioactive waste which is scheduled to last for more than 10 years at a place different from the one where these materials have arisen.

The licence application must be accompanied by further documents as specified in § 3(2) AtVfV (see section on the EIA in Chapter E.2.3 in the reporting on Article 19(2)(ii)):

1. an overview of the most relevant alternatives for the technical procedures, including reasons for the choice, as far as these information may be relevant for the assessment of the admissibility of the intended project according to § 7 AtG,
2. indication of difficulties having become apparent during preparation of the data for the assessment of the requirements within the environmental impact assessment, especially insofar as these difficulties may relate to lack of knowledge and evaluation methods or to technological gaps.

Within the meaning of Article 6(1)(i) of the Convention, this detailed information will enable the authorities and any authorised experts consulted by them to assess all relevant site-related factors which might affect the safety of spent fuel management facilities during their operational life.

Especially for the dry cask storage of spent fuel and heat-generating radioactive waste, the Nuclear Waste Management Commission (ESK) guideline [4-2] makes further requirements – apart from the legal requirements already mentioned – for the structural installations, for the shielding of ionising radiation to be ensured by the latter, for the heat removal from the casks and from the storage building, for the criticality safety to be ensured, and for other areas. This guideline is used as a basis for the licensing of new storage facilities. No regulatory specifications with regard to the extended storage have yet been made.

G.3.2 Impacts on the safety of individuals, society and the environment

In addition to the information outlined in the remarks on Article 6(1)(i), the safety report and the auxiliary documents must contain data on the following topics (see reporting on Article 19 (2)(ii)):

- description of construction and operation: overview of the entire project; plant operating procedures, quality management concept, fire protection concept, documentation etc.,
- operational radiation protection: radiation protection areas in the facility, radiation and activity monitoring in rooms and in the facility, physical radiation protection monitoring of individuals, monitoring of discharges of radioactive substances and environmental monitoring, surveillance of material which is released from the controlled area, measures to reduce radiation exposure of personnel and the environment,
- waste and residual material management: release of cleared material from the operation, conditioning, storage and (if relevant) transfer of radioactive operational waste,
- radiation exposure in the environment: application values for discharges with air and water including substantiation, calculation of the exposure resulting from the discharge of radioactivity and from direct radiation,
- incident analysis: description of the protection goals, possible incidents, incident analysis for operation, radiation exposure as a result of incidents, and

- further effects of facility operation on the environment: description, analysis and evaluation of the effects on man, animals, plants, soil, water, air, climate and landscape as well as cultural and other material assets.

In addition to this, other information relating to the site and the planned facility as outlined above are also relevant in this context. The ESK guidelines [4-2] summarise the requirements in particular for the dry cask storage of spent fuel and heat-generating radioactive waste. Within the meaning of Article 6(1)(ii) of this Convention, this will enable the competent authorities and any authorised experts consulted by them to assess the presumed effects of a spent fuel management facility on the safety of individuals, society and the environment.

G.3.3 Information of the public on the safety of a facility

Projects to construct a spent fuel management facility are publicly announced and the documents are publicly displayed in accordance with the provisions of § 4 AtVfV [1A-10]. The public hearing which may be necessary is regulated in §§ 8 to 13 AtVfV. The public hearing is the oral discussion of the previously filed objections against the planned work, carried out under participation of the authority, the objectors and the applicant. The public hearing is intended to provide those who have raised objections during the period determined by § 7 AtVfV with the opportunity to explain their objections. According to § 12(1) AtVfV, the public hearing is not open to the general public.

Details concerning the related procedures are described in the section on involvement of the public under the remarks on Article 19(2)(ii) in Chapter E.2.3.

This approach, particularly the involvement of the public as defined in the AtVfV and the UVPG [1B-14], ensures that the general public has access to all the necessary information regarding the safety of planned spent fuel management facilities as stipulated by Article 6(1)(iii) of the Joint Convention.

G.3.4 Consultation of neighbouring Contracting Parties

§ 7a AtVfV [1A-10] regulates the procedure for cases of transboundary environmental impacts; this procedure is also relevant in connection with spent fuel management facilities. According to § 7a(1) AtVfV, in cases where

- a project which is subject to EIA may have substantial impacts (as described in the safety report or in the information on other environmental impacts) on the protected entities cited in § 1a AtVfV (man, animals, plants, soil, water, climate, landscape, cultural or other material assets) in a foreign state, or

- another state that might be considerably affected by the impacts makes a corresponding request,

the competent authorities of the foreign state have to be notified of the project with respect to EIA at the same time and to the same extent as the authorities that are to be involved under the terms of the AtG [1A-3], allowing the authority of the other state a reasonable period of time for notifying whether participation in the procedure is requested.

The licensing authority in Germany should ensure that the project is publicly announced in a suitable way in the foreign state, that the authority is specified to whom any objections may be submitted, and that mention is made of the fact that any objections not founded on titles under private law are excluded once the set period for objections has expired.

On the basis of §§ 2 and 3 AtVfV, the German licensing authority will give the involved authorities of the foreign state the opportunity to voice their opinions on the application on the basis of the submitted documents within an appropriate period before reaching its decision. Citizens of that state are accorded equal status with German citizens with respect to their further involvement in the licensing procedure.

§ 7a(2) AtVfV specifies that upon request, the applicant must supply translations of the required summary, as well as any other information about the project which may concern transboundary involvement, in particular concerning transboundary environmental impacts.

According to § 7a(3) AtVfV, consultations are to be held, where necessary, between the supreme German Federal and the authorities of the *Länder* and the competent authorities of the foreign state regarding the transboundary environmental impacts of the project and any measures for avoiding or reducing them.

Furthermore, § 8 UVPG shall also apply to the participation of the authorities in other countries; insofar a protected commodity in another state may be affected.

In addition, Article 37 of EURATOM [1F-1] requires each member state of the European Atomic Energy Community to provide the European Commission with general data relating to any plan for the discharge of radioactive waste in whatever form which will enable it to determine whether the implementation of such a plan is liable to result in the radioactive contamination of the water, soil or airspace of another member state. This also satisfies the requirements of Article 6(2) of this Convention. Such data usually comprise details of the site, the plant, the discharge of radioactivity into the atmosphere or in liquid form during normal operation, the management of solid radioactive waste, any unplanned discharges of radioactive substances, and environmental monitoring.

G.3.5 Measures to avoid unacceptable effects on other Contracting Parties

The effects of the operation of spent fuel management facilities on protected commodities, such as man, animals, plants, soil, water, air, etc., are described in the documents supplied by the applicant, as outlined in the remarks on Article 6(1).

Effects on other Contracting Parties of this Convention which are adjacent to the spent fuel management facility may result from the licensed liquid and gaseous discharges from the plant during normal operation and from possible additional release of radioactivity into the environment during incidents:

- The discharge of radioactivity during normal operation is limited by § 47 of the Radiation Protection Ordinance (StrlSchV) [1A-8] in such a way that the doses resulting from discharges with water and air will not exceed the dose limits specified in Table F-1 for any individual member of the general public per calendar year.

- The release of radioactivity during incidents in spent fuel management facilities is regulated by the provisions of §§ 49 and 50 StrlSchV, respectively, depending on the type of facility. § 49 StrlSchV specifies that for local storage facilities for spent fuel, the doses caused by releases of radioactive substances into the environment in the case of the most severe design basis accident must not exceed the limits specified in Table F-1. In cases falling under the scope of § 50 StrlSchV, the nature and extent of protective measures are stipulated by the competent authority, with due consideration for the individual case, particularly with regard to the hazard potential of the plant and the likelihood of an incident occurring.

Concerning the effects on other Contracting Parties, it is important to consider that the AtVfV prescribes the involvement of the authorities of affected neighbouring states [1A-10] (see above). As such, those authorities will be informed about the possible radiological effects of normal operation of the plant as well as any potential incidents. Provided the specified dose limits, which correspond to the relevant European Union (EU) regulations and to international standards, are also used as a basis by other Contracting Parties, then the effects will also be acceptable to them.

G.4 Article 7: Design and construction of facilities

> ***Article 7: Design and construction of facilities***
>
> *Each Contracting Party shall take the appropriate steps to ensure that*
>
> *i) the design and construction of a spent fuel management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases;*
>
> *ii) at the design stage, conceptual plans and, as necessary, technical provisions for the decommissioning of a spent fuel management facility are taken into account;*
>
> *iii) the technologies incorporated in the design and construction of a spent fuel management facility are supported by experience, testing or analysis.*

G.4.1 General protection goals

For facilities for the management of spent fuel (see Table L-1 to Table L-4) the protection goals according to § 1(2) of the Atomic Energy Act (AtG) [1A-3] apply, namely the

- protection of life, health and property against the hazards of nuclear energy and the detrimental effects of ionising radiation

or those of § 1 of the Radiation Protection Ordinance (StrlSchV) [1A-8], i.e. the

- protection of man and the environment against the harmful effects of ionising radiation.

Furthermore, § 6(2) AtG contains the licensing conditions which ensure that the protection goals are fulfilled. Both cover the stipulations of the Joint Convention.

During the licensing procedure, the competent licensing authorities make sure that the corresponding requirements are fulfilled. This means that constant checks are already performed during the design phase ensuring compliance with the protection goals, both under normal operating conditions and in the event of an uncontrolled accidental release. The design of the facility and the establishment of limits for radioactive discharges in the licence ensure that the radiological impacts on individuals, the society and the environment are limited to a non-hazardous extent in the subsequent operation.

G.4.2 Provisions for decommissioning

The decommissioning and dismantling of a spent fuel management facility is governed by the same legal prerequisites and peripheral requirements as other nuclear facilities. The operation of spent fuel management facilities is licensed for a specified purpose and the facilities must be removed once the licence has expired. There are also regulations governing decommissioning and dismantling. The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has decreed that the Guidelines for dry cask storage of spent fuel and heat-generating waste [4-2] of the Nuclear Waste Management Commission (ESK) must be applied. Section 2.16 of this guideline contains the following provision concerning decommissioning:

> "The storage facility is to be designed and constructed such that it can be decommissioned in compliance with the radiation protection requirements and can either be made available for alternative use or removed. Prior to any further use or demolition of the storage building it is to be demonstrated by measurements that the building is not contaminated or has been sufficiently decontaminated and is free of any inadmissible activation. The requirements under building and waste law are to be observed."

This means that the radiation protection principles and requirements set forth in the Radiation Protection Ordinance (StrlSchV) must be observed during the decommissioning and dismantling of these types of facilities. However, additional regulations from the Closed Substance Cycle and Waste Management Act [1B-13] and the building regulations of the *Länder* must also be observed. Those statutory requirements combine to form the legal framework within which the technical execution of decommissioning is to be planned, which must furthermore be in line with generally accepted technical rules.

G.4.3 Technical bases

The construction of installations in Germany is governed by the commonly accepted technical rules – e.g. the specifications laid down in the German Institute for Standardization (DIN)/European Article Numbering (EAN) standards. In the nuclear sector, the requirements specified in KTA safety standards additionally apply (see the remarks on Article 19(2)(i) in Chapter E.2.2) and the state of the art in science and technology must also be observed.

These standards, as well as the state of the art in science and technology, are derived from experience. Hence, in Germany, the experiences gained from nuclear research installations as well as from industrial application have been incorporated into the regulatory framework. Technical safety standards are issued by the Nuclear Safety Standards Commission (KTA), which is comprised of representatives from research, industry and administrative bodies who pool their experience from the various different areas of nuclear safety.

The development of transport and storage casks is based on many years of experience in the design and manufacturing of such casks, as well as on testing e.g. by drop tests and by numerical analysis based on experimental results. Both publicly and privately funded research programmes (e.g. long-term safety analyses) address specific issues, the results of which are incorporated into the revisions of existing KTA safety standards as well as in the specification of new rules.

G.5 Article 8: Assessment of the safety of facilities

Article 8: Assessment of safety of facilities

Each Contracting Party shall take the appropriate steps to ensure that

i) before construction of a spent fuel management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its time of operation shall be carried out;

ii) before the operation of a spent fuel management facility, updated and detailed versions of the safety assessment and of the environmental assessment shall be prepared when deemed necessary to complement the assessments referred to in paragraph i).

G.5.1 Assessment of safety in the licensing procedure

The assessment of the safety of nuclear facilities for the treatment of spent fuel (storage facilities and the Gorleben pilot conditioning plant), and the assessment of environmental impacts conducted prior to the construction of such a facility, take place within the context of a licensing procedure (see reporting on Article 19(2)(ii)).

An assessment of the safety and environmental impacts conducted prior to commissioning takes place within the context of the accompanying supervision under the relevant nuclear laws.

Regulatory basis

The construction and operation of nuclear facilities for spent fuel management is subject to licensing under the Atomic Energy Act (AtG) [1A-3]. For the building work, a building permit is also required under the Building Code of the respective *Land*.

Applications for licences under the AtG must be submitted to the competent licensing authority. The application must include a statement on the extent to which the nuclear facility ensures the necessary precautions against damage according to the state of the art in science and technology, and meets the requirements of the rules and regulations in force. The nature and content of the documents to be submitted with the application must meet the requirements of the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10], or in the case of facilities for the storage of spent fuel, must fulfil them mutatis mutandis. The necessary documents (see also KTA 1404; Safety Standards of the Nuclear Safety Standards Commission (KTA) in Annex L-(d)) are listed in detail in the reporting on Article 19(2)(ii) and (iii) in Chapter E.2.

Based on the European requirements [1F-12] and in accordance with the Environmental Impact Assessment Act (UVPG) [1B-14], an environmental impact assessment has been conducted as a subsidiary part of the licensing procedure for the construction of nuclear facilities for the storage of spent fuel for which applications have been submitted since 1999. In such cases, the documents have to be supplemented by

- a presentation of the possible effects of the project on humans, including human health, fauna, flora and the biological diversity, soil, water, air, climate, and the landscape, cultural and other material assets as well as the interactions between the aforementioned objects of protection,
- an overview of the technical process alternatives examined by the applicant, and the reasons for selection, if significant, as well as by
- notes on any difficulties experienced in compiling the information for the assessment of environmental impacts.

Regulatory reviews

In the licensing and supervision procedure, the competent authorities are responsible for the review of the documents submitted and the licensing prerequisites. According to § 20 AtG [1A-3], experts may be consulted for it. The basic requirements governing expert opinions are formulated in a directive [3-34]. The independent experts review in detail the documents and licensing prerequisites submitted by the applicant. On the basis of the evaluation standards, details of which must be included in the expert opinion, they perform their own tests and calculations – preferably using methods and programmes other than those of the applicant – and give an expert assessment of these results. Unless there are specific provisions governing the safety assessment of nuclear facilities for the treatment of spent fuel, any relevant rules from the existing set of rules and regulations for the safety assessment of nuclear power plants are applied mutatis mutandis (e.g.

[3-23], [3-33-2], [3-0-1], [3-0-2] and KTA 2101). Specific requirements for nuclear facilities for the treatment of spent fuel may be derived from international recommendations, such as those of the International Atomic Energy Agency (IAEA) [3-0-2].

A licensing prerequisite is the reliability of persons responsible for the handling of radioactive material. According to § 12b AtG, the reliability check is carried out by the competent authorities as a protection against unauthorised acts which may lead to a diversion or major release of radioactive material [1A-19].

Requirements on design and operation

The requirements for design and operation of facilities for spent fuel management are presented exemplarily by means of the requirements for the dry storage facilities for spent fuel:

Regarding the technical design and the operation of facilities for the dry cask storage of spent fuel, the Guidelines for dry cask storage of spent fuel and heat-generating waste [4-2] of the Nuclear Waste Management Commission (ESK) shall be applied.

The following radiological protection goals must be met in order to ensure that the precautions against damage reflect the state of the art in science and technology:

- Safe enclosure of the radioactive inventory
  The barriers or spent fuel casks that ensure the confinement must retain sufficient integrity (monitoring of sealing function, formulation of a repair concept) under all credible circumstances (hazardous incidents, accidents, ageing, impacts, etc.).

- Avoidance of unnecessary radiation exposure, limitation and monitoring of the radiation exposure of operating personnel and the general population
  Adherence to the limit values of the effective dose and the organ doses for individuals of the public and for occupationally exposed persons according to §§ 46 and 55 of the Radiation Protection Ordinance (StrlSchV) [1A-8] as well as adherence to the accident planning reference levels according to § 49 StrlSchV, even in the most unfavourable case of an accident; avoidance of unnecessary radiation exposures and dose reduction according to § 6 StrlSchV (receiving and dispatching checks on the fuel assembly casks, formulation of a radiation-protection concept, division of the storage facility into radiation protection zones, radiation monitoring in the storage facility and the vicinity).

- Reliable maintenance of subcriticality
  Proof of the criticality safety of the fuel assemblies during storage shall be demonstrated for the least favourable conditions to be expected during specified normal operation (limitation of the enrichment of the fuel assemblies, exclusion or limitation of neutron moderation, use of neutron absorbers, maintenance of the appropriate spacing) [DIN 25403], [DIN 25478], [DIN 25712].

- Sufficient removal of decay heat power
  Even in the case of combined impacts on the effectiveness of heat removal, the operators must guarantee that only admissible temperatures will occur. The mechanisms of heat removal must be independently operative (passively by natural convection).

From these protection goals, further requirements can be derived which are essential for compliance with the above targets:

- shielding of the ionising radiation,

- design, execution, and quality assurance suitable for operation and maintenance (KTA 1401, see Safety Standards of the Nuclear Safety Standards Commission (KTA) in Annex L-(d)),
- safety-oriented organisation and performance of operation,
- safe handling and shipment of the radioactive materials (see also [IAEA 12b]),
- design against accidents and provision of measures to reduce the harmful effects of events that exceed the design parameters (incident analysis). Calculation of the effects of hazardous incidents and of pre-existing pollution prevailing at the site before the facility is constructed is regulated by [2-1] and [3-33-2].

In the context of the accident analysis, as part of the safety report, distinction is made between external and internal events, the latter being caused by the spent fuel treatment facilities themselves. An assessment of these events is made by the competent licensing authority as part of the licensing procedure. Recommendations for disaster control are made in [3-15] (see reporting on Article 25).

In connection with dry storage, the following internal events generally have to be considered:

- mechanical impacts, such as the crash of a fuel assembly cask, collision of a cask upon handling, and the crash of a load onto the cask (see drop test examples of the Federal Institute for Materials Research and Testing (BAM) in Figure G-1) and
- fire.

Figure G-1: Drop test of a transport and storage cask for vitrified waste at the test facility of the Federal Institute for Materials Research and Testing (BAM) within the framework of an approval procedure under traffic law (Copyright: BAM)

According to the guidelines, external natural impacts and man-made impacts from outside are taken into consideration (see also [BMU 13b], [3-62]):

- external natural impacts such as storm, rain, snow, frost, lightning, flooding, landslides and earthquakes,
- man-made impacts from outside such as the effects of harmful substances (e.g. poisonous or explosive gases), blast waves caused by chemical explosions, fires (e.g. forest fires) spreading to the facility, mines caving in, and aircraft crashes.

Further impacts have to be taken into account depending on the conditions at the respective sites. For example, interactions with a neighbouring power plant are also considered, e.g. the collapse of structures, a turbine failure, or the failure of vessels with high energy content, as far as debris from such events may affect the storage facility.

The safety-related requirements relate to a time-limited storage of the waste. For concrete verification, the periods applied for in the respective licensing procedures have to be applied. In the storage licences granted so far, this period has been 40 years, which is usually applied as the yardstick for other licensing procedures. By imposing further conditions at a later stage during the operating lifetime, the competent authority may demand adaptations of the facility to comply with the state of the art in science and technology as far as this is necessary to fulfil the safety requirements (see § 17(1)(3) AtG [1A-3]). No regulatory specifications with regard to the extended storage have yet been made.

G.5.2 Safety assessment in the supervisory procedure prior to operation

The review of the safety of nuclear facilities that accompanies their construction prior to commissioning is carried out by the competent supervisory authority under the AtG, i.e. the competent supreme Land authority. The authority determines whether the statements contained in the documents submitted, and any supplementary requirements in the licence, are being observed and implemented. Independent experts are also consulted for these supervisory duties.

If there are any relevant deviations from the state of the art in science and technology as specified in the licensing documents, modifications become necessary according to § 7(1) or § 6 AtG for which a modification licence is required; in this connection, all documents also have to be adapted to the current state of the art in science and technology. Here, it has to be checked whether the modified facility satisfies overall the imperative of damage precaution. This check extends to all effects of the modification on the safety of the facility and its operation. A deviation from the licensed status or operation of the facility is considered as being substantial if it does not show merely irrelevant consequences for the safety level at the facility. Modification licences are applied for at the competent licensing authority by the operator of the respective nuclear facility, sometimes within the framework of an order issued by the nuclear supervisory authority.

Figure G-2: Transport cask storage building at Ahaus (Copyright: GNS)

According to the guidelines of the ESK [4-2], the commissioning of a storage facility (see Figure G-2 showing the transport cask storage building at Ahaus as an example of a fuel store) has to include a commissioning programme consisting of the commissioning tests of all installations. This programme serves for proving that the installations have been properly installed for the planned operations and can be operated as specified, which ensures that the protection goals are met. The commissioning programme is approved by the competent authority.

G.5.3 Stress test

The earthquake off the eastern coast of Japan on 11 March 2011 and the resulting flooding by a tsunami triggered a nuclear disaster at the Fukushima nuclear power plant site. Even though the initiating events of the nuclear disaster in Japan, in particular the magnitude of the earthquake and the height of the tidal wave, cannot be applied directly to European and German conditions, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU, now BMUB) has initiated the performance of not only a robustness test for German nuclear power plants and research reactors, but also of a stress test for the facilities for the management of spent fuel and radioactive waste in Germany as well as for the uranium enrichment plant at Gronau and the fuel fabrication plant at Lingen. The ESK was commissioned to develop appropriate assessment concepts for these facilities. The results of the stress test are documented in two ESK statements [4-11].

The review was based on a questionnaire that was answered by the operators of the facilities. Apart from questions about the load cases earthquake, flooding, heavy rain, other weather-related events, failure of the electrical energy supply, plant-internal fire, fires outside the plant, aircraft crash, and blast pressure wave, the questionnaire also contained the stress level or levels of protection that the ESK applied as a basis in the assessment. The following questions were used as assessment criteria:

a) Will the vital functions be maintained at the stress levels?

b) Which maximum effects are realistically conceivable at the stress levels?

c) Are any cliff edge effects foreseeable and if so, have they been taken into account?

d) On which basis has the assessment been made and is it plausible and comprehensible?

Issues related to the security (physical protection) of facilities were not considered in this review. In terms of the nuclear waste management facilities, the results of the stress test can be summarised as follows:

The storage of the spent fuel and heat-generating radioactive waste is based on a robust protection strategy, in which compliance with the essential protection goals during storage in normal operation and in case of accidents is ensured primarily by the metallic thick-walled containers. The design of the containers furthermore ensures that, even in the event of a beyond design basis accident, no major disaster control measures are required. According to the ESK discussion paper on the extended storage of spent fuel and other heat-generating radioactive waste [4-20], the current operating experience with casks and storage facilities combined with regular safety reviews and systematic ageing management measures principally justify the expectation that the existing safety functions will be maintained also for an extended storage beyond 40 years.

The investigations and reviews have shown that the storage of spent fuel and heat-generating radioactive waste achieve the highest degree of protection in almost all load cases. Also in the case of the on-site storage facility Brunsbüttel, the original licence of which became ineffective as a result of a decision of the Federal Administrative Court of 8 January 2015, there were no signs of insufficient safety. It was rather the scope of the investigations and assessments in the licensing procedure that have been criticised.

The facilities for the treatment of spent fuel, the pilot conditioning plant (PKA) at Gorleben and the not-yet dismantled operating sections of the Karlsruhe reprocessing plant (WAK) have significant reserves against beyond design basis events. They reach the highest stress level or the highest level of protection for many postulated load cases.

Regarding the storage facilities for low and medium active waste as well as the stationary facilities for conditioning low and medium active waste, the examinations showed that even in the case of beyond design basis accident events, any serious consequences will be limited to a region not exceeding 100 meters in diameter around the respective facility. Authorities must therefore decide for a maximum range of 100 meters around the facility whether measures such as access bans need to be taken. In that regard, these facilities also proved to be robust. Any prolonged flooding of the facilities or a tidal wave propagating through the buildings has practically no radiological consequences.

Regarding repositories, the studies focused on their surface installations. The stress test for the repositories that were included in the examinations (Morsleben repository for radioactive waste (ERAM), Konrad) and for the Asse II mine showed that a transgression of the intervention limits for an evacuation of the surrounding area can be excluded under the assumed loads.

Hence, due to postulated beyond design basis load cases, no failure of components or measures that would lead to a sudden increase in the radiological impact outside the plant ("cliff edge effect") has to be feared for any of the facilities that have been assessed. Furthermore, no deficits in the design requirements of the facilities that were assessed have become visible in the stress test.

G.6 Article 9: Operation of facilities

> ***Article 9: Operation of facilities***
>
> *Each Contracting Party shall take the appropriate steps to ensure that*
>
> *i) the licence to operate a spent fuel management facility is based upon appropriate assessments as specified in Article 8 and is conditional on the completion of a commissioning programme demonstrating that the facility, as constructed, is consistent with design and safety requirements;*
>
> *ii) operational limits and conditions derived from tests, operational experience and the assessments, as specified in Article 8, are defined and revised as necessary;*
>
> *iii) operation, maintenance, monitoring, inspection and testing of a spent fuel management facility are conducted in accordance with established procedures;*
>
> *iv) engineering and technical support in all safety-related fields are available throughout the time of operation of a spent fuel management facility;*
>
> *v) incidents significant to safety are reported in a timely manner by the holder of the licence to the regulatory body;*
>
> *vi) programmes to collect and analyse relevant operating experience are established and that the results are acted upon, where appropriate;*
>
> *vii) decommissioning plans for a spent fuel management facility are prepared and updated, as necessary, using information obtained during the time of operation of that facility, and are reviewed by the regulatory body.*

G.6.1 Licence to operate the facility

In Germany, spent fuel management only involves the operation of storage facilities as the licence of the pilot conditioning plant (PKA) at Gorleben is currently limited to the repair of defective casks and no repository is available yet. Therefore the following will only deal with said facilities.

The storage facilities have a licence for an operating life of 40 years from the beginning of emplacement.

The entire operation should be structured in a suitable manner so as to ensure the safe performance of the operational processes. In particular, the administrative prerequisites regarding personnel, organisation and safety must be fulfilled. Clear instructions must be formulated in an operating manual for operational processes, abnormal operating conditions, accident management and elimination of the consequences of incidents and accidents. Competencies and responsibilities must be clearly defined. The competent authority supervises compliance with the conditions and requirements.

At each facility, cold testing with one cask for each cask type licensed for storage is performed for the entire handling procedure, including radiation protection measures, before casks are stored there for the first time.

G.6.2 Definition and revision of dose reference levels

All operational processes and the measures to be taken in case of incidents are described in form of clear service instructions, which are laid down in an operating manual in fulfilment of the Guidelines for dry cask storage of spent fuel and heat-generating waste [4-2] of the Nuclear Waste

Management Commission (ESK). In particular, all aspects relating to safety must be addressed, and the procedure in the event of modifications or additions of components and procedures must be specified. This is intended to ensure that the personnel is able to promptly and confidently initiate and perform the necessary measures in case of abnormal operation or incidents and that the limits defined in the Radiation Protection Ordinance (StrlSchV) [1A-8] as well as the limits specified in the licence are kept. This procedure is subject to regulatory supervision. Should it turn out during the facility's operating lifetime that there is a need to adjust these limits; this is initiated by the licensing authority upon application of the licence holder.

G.6.3 Compliance with specified procedures

For storage facilities, the assumptions and boundary conditions for cask properties used in the safety inspections are compiled in the form of technical acceptance criteria. Performance criteria are drawn up for compliance with the technical acceptance criteria. This also includes operating instructions and test procedures which must be taken into account during the loading of the casks. Compliance is supervised by experts from the competent supervisory authority.

The effectiveness of the lid seals has to be verified upon installation. According to the Guidelines for dry cask storage of spent fuel and heat-generating waste [4-2] of the ESK, the standard helium leak rate must not exceed a value of 10^{-8} Pa·m³/s for the entire lid barrier. A monitoring system is used for operational monitoring of the sealing function of the casks in the storage facility. This sends a signal to a central monitoring point as soon as a malfunction occurs in one of the two cask sealing systems. The monitoring system allows the affected cask to be identified.

The prescribed condition of the safety-relevant installations of the storage facility is ensured by regularly recurring inspections. Their frequency depends on the safety significance of the component to be inspected. The recurring inspections are laid down in a testing manual. The results of the recurring inspections are documented and are available for the purpose of long-term monitoring.

The operation of the facility is monitored so that any safety-significant disturbances of operation and accidents will be reliably detected and the counter-measures specified in the operating manual can be taken.

In the event of failures or malfunctions of safety-significant components and systems, repair measures will be initiated immediately in consultation with the competent authority.

Furthermore, regarding components or component parts that may need to be replaced, care will be taken that this work can be executed without any major disturbance of operations in the storage facility and preferably shielded off from the radiation field of the storage casks and that adequate accessibility is provided.

Each emplacement, removal or relocation of casks is documented. In this connection, the constant adherence to the maximum radiological, thermal and mechanical loads on which the design of the storage building is based is documented.

Regular written operation reports are prepared about the operation of the storage facility, containing the information about all relevant operational processes. On the whole, the report is to provide evidence that the radiological, thermal and static boundary conditions are adhered to with the casks that are emplaced.

A monitoring concept is drawn up in order to control long-term and ageing effects during the storage facility's operational period. Here, a general distinction is made between parts and components that are designed for the entire period of use of the facility, and those that may need to be replaced. The essential safety-related properties of the systems, parts and components are ensured for the entire operating period. In particular, the condition of the lifting trunnions must allow the casks to be moved within the facility at any time.

Also the reporting obligation of the condition of the storage building and of the components necessary for storage every 10 years is subject of the monitoring concept.

Regulatory supervision ensures compliance with the procedures on operation, maintenance, monitoring, inspection and testing established in the nuclear licensing procedure for spent fuel management facilities.

G.6.4 Availability of technical support

Report on the measures to ensure engineering and technical support during the operating lifetime of the facilities by providing adequate competent staff was already made in the remarks on Article 22(i).

The technical systems and equipment used for outward shipment of the fuel assembly casks are kept available until all casks loaded with fuel assemblies have been removed.

All auxiliary systems, such as cranes and monitoring systems are provided and maintained throughout the operating lifetime of the facility.

Periodic testing is performed on all essential systems and equipment of the facility. The respective tests are specified in a testing manual. The technical equipment required for this purpose is kept available throughout the facility's operating lifetime.

G.6.5 Reporting of significant incidents

The obligation incumbent upon operators of facilities licensed according to § 6 or § 7 of the Atomic Energy Act (AtG) [1A-3] to report accidents, incidents and other safety-significant events to the supervisory authority is regulated in the Ordinance on the Nuclear Safety Officer and the Reporting of Incidents and other Events (AtSMV) [1A-17]. The reporting criteria are formulated in the AtSMV according to the type of facility as far as possible.

The operator of the nuclear facility reports an event to the competent supervisory authority of the *Land* if the event is reportable according to the reporting criteria. The operator is responsible for the accurate and complete reporting of a reportable event in due time. The supervisory authority on its part, following its first assessment of the circumstances, reports the event to the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and at the same time to the central registration agency of the Federal Office for the Safety of Nuclear Waste Management (BfE). The BfE checks the classification of the event once more on a federal level. If it is not possible to provide all necessary details by means of the reporting form until the deadline for making a written report, the report has to be marked as provisional. A completed report (final report) has to be submitted to the supervisory authority as soon as the missing information has become available, at the latest, however, after two years.

Reportable events are classified into one or several reporting categories by applying the reporting criteria on the basis of a first assessment of the cause of the event. This procedure considers in particular that the authority must be able to take precautionary measures even if an in-depth assessment of the event is not yet available.

Category S (Immediate report – deadline: immediately)
Events have to be allocated to Category S that have to be reported immediately to the supervisory

authority to enable the latter to initiate or order measures at very short notice if necessary. This also includes events that indicate acute safety deficiencies. Reports of Category S have to be made immediately by telephone or in written form by communications facilities; after no longer than five days following first knowledge about the event, any supplement to or, if necessary, correction of the report has to be submitted on a special reporting form.

Category E (Urgent report – deadline: within 24 hours)
Events have to be allocated to Category E that do not require any immediate action by the supervisory authority but whose cause has to be clarified quickly and, if necessary, rectified within an appropriate period of time for reasons of safety. These are usually events of potential – but not acute – safety significance. Reports of category E have to be made after no longer than 24 hours following the event at the latest by telephone or in written form by communications facilities; after no longer than five days following first knowledge about the event, any supplement to or, if necessary, correction of the report has to be submitted on a special reporting form.

Category N (Normal report – deadline: within five working days by means of reporting form)
Events have to be allocated to Category N that are of little safety significance. They diverge only to a minor extent from the routine operational events of the normal specified plant state and operation. They are evaluated in order to find possible weaknesses before any major disturbances can occur.

Category V (Prior to commissioning – deadline: within ten working days by means of reporting form)
Events have to be allocated to Category V that occur prior to the commissioning of the facility and about which the supervisory authority has to be informed with a view to the later safe operation of the facility.

Irrespective of the official reporting procedure according to the AtSMV reporting ordinance, the classification of the reportable events is carried out by the operator of the nuclear facility according to the International Nuclear Event Scale (INES) assessment scale of the International Atomic Energy Agency (IAEA). The INES classification is notified together with the AtSMV report. The German INES officer, who has been appointed by the BMUB, checks the correctness of the INES classification for each event. The final decision on the classification is made by the BMUB and the INES officer. At present, the functions of the INES officer are fulfilled by a member of staff of the "*Gesellschaft für Anlagen- und Reaktorsicherheit*" (GRS) gGmbH on behalf of the federal authority.

G.6.6 Collection and use of operating experience

The reporting and assessment procedure laid down in the AtSMV is an essential basis for the evaluation of operating experience. Once the supervisory authority has obtained and evaluated all the information relating to a reportable event, it specifies – following close consultation with the operator – any rectifying measures that may be necessary as well as the provisions to be made.

The reportable events are registered and evaluated at the incident registration centre of the BfE on behalf of the BMUB. The BfE publishes the results in annual reports. If any events are of a special and generic significance, GRS will prepare a so-called information notice on behalf of the BMUB. Information notices shall serve to enable the operators of comparable facilities to check the applicability of the event to their facilities and, if required, initiate appropriate improvement measures. They include a description of the circumstances, the results of the root cause analysis, the assessment of the safety significance, the measures taken or planned by the operator, and as the most essential element, recommendations for examinations and possibly for the taking of remedial action in other facilities.

Other safety-relevant findings from initial start-up, specified normal operation (especially in the case of maintenance, inspections and repairs) and in-service inspections are also documented and submitted to the supervisory authority. Any consequences derived from the evaluation of the incidents are taken into account in the operating procedures.

The monitoring concept ensures the monitoring of the overall status of the facility and as a minimum requirement ensures the following:

- The condition of the storage building and the components required for storage are controlled by means of walk-downs and suitable measurements.
- Recurrent subsidence measurements are performed for the storage building.
- The external condition of the storage casks is monitored by inspections.
- The findings from in-service inspections are evaluated.

Experiences from the operation of similar plants are incorporated into plant management. For this purpose, procedures are put in place to ensure an exchange of experiences (e.g. on the basis of operating reports) between plant operators.

In addition, on behalf of the BMUB, GRS evaluates generally accessible international sources with regard to any disturbances and accidents in foreign nuclear fuel cycle facilities. The information is stored in the VIBS database (database for incidents in fuel cycle facilities). At regular intervals, the supervisory authorities are informed about newly registered events by means of database excerpts and short assessments; they will then check whether any new insights can be gained from them to improve the safety of the German facilities.

For the purpose of an international exchange of experiences, Germany also participates in the Fuel Incident Notification and Analysis System (FINAS) that was set up by the OECD/NEA for nuclear fuel cycle facilities following the Incident Reporting System (IRS) for nuclear power plants. Within the context of FINAS, the participating countries exchange information on disturbances and incidents with general safety significance with a view to learning lessons for improving plant safety wherever possible.

G.6.7 Preparation of decommissioning plans

Spent fuel treatment facilities are designed and constructed in such a way that they can be decommissioned in compliance with the regulations on radiological protection and then either be reused or disposed of. Proof to this effect is checked during the course of the nuclear licensing procedure. Information on changes to the licensed condition of the facility must either be submitted to the supervisory authority or in case of significant modifications to the licensing authority for approval. Before further use or demolition of the storage building, proof that the building is either not contaminated or has been decontaminated sufficiently and is free of inadmissible activation must be furnished in the form of measurements. The requirements under construction and waste law must also be observed. The supervisory authorities of the *Länder* ensure that a corresponding exchange of experience takes place at the level of supervision and with the experts also consulted.

G.7 Article 10: Disposal of spent fuel

> ***Article 10: Disposal of spent fuel***
>
> *If, pursuant to its own legislative and regulatory framework, a Contracting Party has designated spent fuel for disposal, the disposal of such spent fuel shall be in accordance with the obligations of Chapter 3 relating to the disposal of radioactive waste.*

Spent fuel is to be disposed of together with heat-generating radioactive waste from reprocessing. The issue on the search for a repository for spent fuel and heat-generating radioactive waste from reprocessing is reported in Chapter H.3.2.

H Safety of radioactive waste management

This section deals with the obligations under Articles 11 to 17 of the Convention.

Developments since the Fifth Review Meeting:

In July 2014, the Nuclear Waste Management Commission (ESK) published a statement on the state of preparations concerning the provision of radioactive waste packages for the Konrad repository. There, relevant issues for the use of the Konrad repository are treated in detail, prioritised according to their relevance, and the potential for optimisation is identified taking into account the current work progress.

In October 2014, the ESK published a statement on the return of vitrified waste from reprocessing in other European countries [4-14]. Here, the ESK is focusing on the specific features of the approval of the casks under traffic law provisions, and considered how transportability of the casks can be ensured in case of failure of a primary lid seal after expiration of the storage licence.

In May 2015, the ESK published a statement [4-16] on the implementation of the Guidelines for the storage of radioactive waste with negligible heat generation. Here, a generic assessment of the actual condition of the waste packages is made.

H.1 Article 11: General safety requirements

Article 11: General safety requirements

Each Contracting Party shall take the appropriate steps to ensure that at all stages of spent fuel management, individuals, society and the environment are adequately protected against radiological hazards.

In so doing, each Contracting Party shall take the appropriate steps to

i) ensure that criticality and removal of residual heat generated during spent fuel management are adequately addressed;

ii) ensure that the generation of radioactive waste associated with spent fuel management is kept to the minimum practicable, consistent with the type of fuel cycle policy adopted;

iii) take into account interdependencies among the different steps in spent fuel management;

iv) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards;

v) take into account the biological, chemical and other hazards that may be associated with spent fuel management;

vi) strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation;

vii) aim to avoid imposing undue burdens on future generations.

H.1.1 Ensuring subcriticality and residual heat removal

The nuclear rules and regulations require that criticality is to be prevented and residual heat is to be removed in a suitable form. Within the framework of a comprehensive site-specific safety analysis e.g. for the Konrad repository, studies have been carried out into criticality safety/maintenance of subcriticality and into the thermal influence on the host rock. The results were implemented in the waste acceptance requirements for disposal for the Konrad repository [BfS 95] and stipulated with the plan approval decision for the Konrad repository of 22 May 2002. It is therefore ensured for the operational and post-operational phases of this facility that each criticality is avoided and that the residual heat arising is taken into account.

Furthermore, the remarks on Article 4 apply analogously to Articles 11(i) to (vii).

H.1.2 Limitation of the generation of radioactive waste

According to the guideline relating to the control of radioactive residues and radioactive waste of 19 November 2008 [3-60], the waste producer has to present to the competent *Land* authority a waste management concept for all kinds of radioactive waste arising, containing details about the technical and organisational provisions for collection and registration and also describing the intended paths of non-hazardous recycling and of treatment and packaging. Any modifications of this concept have to be updated in the documentation and presented to the competent supervisory authority.

Furthermore, the remarks on Article 4 apply analogously to Articles 11(i) to (vii).

H.2 Article 12: Existing facilities and past practices

Article 12: Existing facilities and past practices

Each Contracting Party shall in due course take the appropriate steps to review

i) the safety of any radioactive waste management facility existing at the time the Convention enters into force for that Contracting Party and to ensure that, if necessary, all reasonably practicable improvements are made to upgrade the safety of such a facility;

ii) the results of past practices in order to determine whether any intervention is needed for reasons of radiation protection bearing in mind that the reduction in detriment resulting from the reduction in dose should be sufficient to justify the harm and the costs, including the social costs, of the intervention.

H.2.1 Safety of existing facilities

In Germany, all facilities existing at the time when the Joint Convention entered into force have already demonstrated in principle their adequate safety within the licensing procedures and their operation. Construction and operation have to be such that the necessary precaution against damage has been taken in line with the state of the art in science and technology. The competent licensing authority has confirmed this through granting the licence. Following the commissioning of a facility, its safety is also reviewed by the authorities as part of their nuclear supervisory role.

The general requirements regarding the precautionary measures to be taken are stipulated in the Atomic Energy Act (AtG) [1A-3], in the Radiation Protection Ordinance (StrlSchV) [1A-8] and in other legal and subordinate regulations. The safety requirements of the IAEA (above all

International Atomic Energy Agency (IAEA) Safety Standards Series No. GSR Part 5 [IAEA 09b]) are also observed.

The protection goals extend to the protection of the local population in the vicinity of the facility, protection of the environment, protection of the operating personnel, and the protection of property against the effects of ionising radiation (see reporting on Article 11 and 4, respectively). Compliance with these protection goals also satisfies the requirements of the Joint Convention. This is ensured by nuclear licensing and the corresponding supervision.

In the following, a distinction is made between facilities for the treatment and storage of heat-generating radioactive waste and facilities for the treatment and storage of radioactive waste with negligible heat generation.

Safety of facilities for the treatment and storage of heat-generating radioactive waste

In the Gorleben transport cask storage facility (TBL-G), not only spent fuel but also vitrified high level waste from reprocessing in France (*Colis Standard de Déchets-Vitrifiés;* CSD-V) is stored in transport and storage casks. The return of this waste ended in November 2011. The same safety requirements apply to the storage of high level waste in the TBL-G as those referred to in Article 5.

The vitrified intermediate level decontamination and flush waters from reprocessing in France (*Colis Standard de Déchets-Boues;* CSD-B*)* were originally also dedicated to be stored at TBL-G. The entry into force of the Repository Site Selection Act (StandAG) in 2013 resulted in the amendment to the AtG. According to § 9a(2a) AtG, the operator of installations for the fission of nuclear fuels for the commercial generation of electricity has to ensure that the solidified fission product solutions from the reprocessing of spent fuel abroad will be taken back and stored in on-site storage facilities according to para. (2), sentence 3 until their delivery to a facility for the disposal of radioactive waste. To this end, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) presented a concept, which provides for the storage of the five casks with intermediate level radioactive waste in the on-site storage facility Philippsburg, Baden-Wuerttemberg. The return is scheduled for 2019.

Furthermore, the concept provides for equal distribution of the expected 21 casks with vitrified high level radioactive waste from reprocessing in Sellafield, UK, to on-site storage facilities at Biblis in Hessen, Brokdorf in Schleswig-Holstein and Isar in Bavaria.

Further procedure was agreed between BMUB, the electric power utilities (EVU) and the *Länder*. It is the task of the EVU to submit corresponding licence amendment requests for transportation and storage.

For the Ahaus transport cask storage facility, the storage of compacted hulls and structural parts of German fuel assemblies (*Colis Standard de Déchets-Compactés;* CSD-C) from the French reprocessing plant at La Hague has been applied for. A new cask concept is currently under preparation; the licensing procedure has not yet been concluded.

The high active waste concentrate (HAWC) solutions arising during the operation of the Karlsruhe Reprocessing Plant (WAK) were fully vitrified at the Karlsruhe Vitrification Plant (VEK) between September 2009 and November 2010. Together with the solutions generated as part of the flushing of the plant, this resulted in a total of 140 canisters. The canisters were loaded into five transport and storage casks of the CASTOR® HAW 20/28 CG type and transferred to the Zwischenlager Nord (ZLN). The former storage facilities and the VEK are being dismantled; this forms part of the decommissioning of the reprocessing plant.

Apart from the vitrified waste from the VEK, spent fuel from operation of the Greifswald and Rheinsberg nuclear power plants, shut down in 1990, and fuel assemblies from the compact sodium-cooled nuclear reactor plant, Karlsruhe (KNK II) and the nuclear ship Otto Hahn are also stored in the ZLN.

The confinement of the radioactive substances is ensured by a system of technical and process-based barriers. The technical barriers include, e.g., the casks with their sealing systems or the building parts, such as hot cells, but also the inner packaging, such as the stainless-steel canister and the glass matrix as such. The process-based barriers include special ventilation measures, like e.g. directed airflows in the room and cell exhaust air due to pressure differences and retention systems.

The number and technical design of the barriers are tailored to the state of matter (solid, liquid, gaseous) and activity inventory of the substances to be retained.

The effectiveness of the barriers is monitored in the cells, work rooms and operating rooms by devices for the detection of leakages, pressure deviations and airborne radioactivity in the cells.

Safety of facilities for the treatment and storage of radioactive waste with negligible heat generation

Radioactive waste with negligible heat generation is put in storage, either at the place where it is generated or in a central facility, until it can be disposed of in a repository. As a repository in Germany will not be available before the year 2022, conditioning has to be such that safe storage is guaranteed even for periods of up to 20 years. Recommendations for the storage of radioactive waste with negligible heat generation irrespective of the kind of storage are made in [4-3] (see reporting on Article 15(i)).

Different facilities and methods are used for the conditioning of radioactive waste (see Table L-5). In the case of liquid waste, the radioactive components are separated through evaporation, ion exchange, filtration or chemical precipitation. Solid waste is burnt or compacted if necessary in order to reduce its volume. Afterwards, it is safely confined in containers. The conditioning plants are almost all assigned to specific nuclear facilities and, together with the other facilities and industrial premises, are subject to licensing, monitoring and supervision by the competent local authority. The safety of the conditioning plants was assessed in the licensing procedure. During operation, regulatory control ensures that safety-related requirements are fulfilled.

The confinement of radioactive substances during the storage of radioactive waste is ensured by a system of technical barriers and supplementary measures. This can be achieved with a variety of different approaches and may include, for example, integration into the matrix of the waste product, confinement in waste containers or, where applicable, the barrier function of buildings and ventilation systems with retention devices. Overall, safe enclosure can be achieved by one barrier or the combined effects of several barriers.

Compliance with the prescribed specifications is ensured by means of monitoring and supervision.

Within the context of analysing hazardous incidents, external impacts are also taken into consideration. On this basis, the authority decides which precautionary measures are to be taken for the facility.

Several facilities take measures to ensure safety during long-term storage. These comprise, e.g., updates of the documentation pertaining to the waste, technical inspections of the waste packages and – if necessary – their repackaging or emplacement in additional enveloping containers. The requirements for long-term storage are described in detail in the reporting on Article 15(i).

As expressed in the reporting on Article 32(2)(iii), two different types of storage facilities in Germany accept radioactive waste, depending on its origin. These facilities differ from each other not so much in their technical design but in the associated responsibilities.

One group is formed by the storage facilities of the operators of nuclear facilities who – according to the polluter-pays principle – are responsible for the lawful and safe treatment of their radioactive waste. These storage facilities require a licence according to § 7 StrlSchV [1A-8] to be issued by the respective competent *Land* authority. In addition, radioactive waste can be stored within the power plant facility covered by the licence pursuant to § 7 AtG [1A-3].

In contrast, radioactive waste from research, industrial or medical application are to be delivered to *Land* collecting facilities (see Berlin *Land* collecting facility as an example in Figure H-1) unless it is stored at the originator's site. According to § 9a AtG, these *Land* collecting facilities have to be established by the *Länder* for the radioactive waste generated on their territory. It is also possible for several *Länder* to agree by contract to jointly use one common *Land* collecting facility.

The handling of the radioactive waste within the *Land* collecting facilities also requires licensing according to § 7 StrlSchV by the competent *Land* authority. Within the licensing procedure it is examined whether relevant safety requirements are fulfilled (see reporting on Article 15). If the radioactive waste is not only stored but also treated at the *Land* collecting facility, the regulations have to be applied accordingly (see reporting on Article 15).

An application to the *Land* collecting facilities for the delivery of radioactive waste must be submitted in writing by the delivering party and accompanied by a waybill. On the basis of these documents it is checked whether the preconditions for acceptance of the radioactive waste have been met. The acceptance criteria of the *Land* collecting facilities differ from one *Land* to another, and are laid down in the respective regulations for use. They depend on the respective licensing situation and on the availability of conditioning equipment. The actual acceptance of the declared radioactive waste follows the incoming inspection by the *Land* collecting facility.

If the radioactive waste fails to meet the preconditions stipulated in the respective regulations for use of the *Land* collecting facility, the latter may refuse to accept it, and report this to the supervisory authority responsible for the delivering party. In such cases, the waste will remain in the hands of the delivering party until it has been transformed into a condition conforming to the regulations for use, and the *Land* collecting facility is willing to accept it. Alternatively, the radioactive waste may be delivered by special agreement, subject to the consent of the competent supervisory authority. Upon acceptance, an incoming inspection is performed.

Figure H-1: Berlin *Land* collecting facility (Copyright: HZB)

When the radioactive waste is delivered to the *Land* collecting facility, it passes into the ownership of the latter on the basis of contractual provisions. This also applies to raw waste. The waste producer's duties in connection with conditioning are thus adopted for this waste by the operator of the *Land* collecting facility.

The acceptance criteria are laid down in the licence in line with the state of the art in science and technology. Each year, the individual operators of *Land* collecting facilities hold a meeting for the purpose of exchanging information.

Recommendations for the storage of radioactive waste with negligible heat generation [4-3] also contain requirements for the monitoring of the stored waste, i.a. the visual inspection of the outer surfaces of certain waste packages as well as the separate storage and recurring checking with visual inspection of reference packages. Any safety-relevant findings and results have to be reported to the supervisory authority responsible for storage.

H.2.2 Past practices

Past practices as defined by this Convention, such as the use of radium in the production of luminous paint or of thorium in the manufacture of gas mantles etc. in the first half of the twentieth century resulted in a number of individual sites in Germany which were contaminated to a limited extent. These contaminated sites have been or are currently being remediated for radiological and other reasons. Cataloguing and categorisation of such legacy sites has largely been completed in Germany.

Past practices with respect to uranium mining and milling were carried out at a large number of sites especially in Saxony which have been discontinued prior to 21 December 1962 and therefore do not fall into the responsibility of the Wismut GmbH for carrying out remediation measures. According to the national requirements of the Federal Republic of Germany, which are in line with international requirements, the amount of residues from former uranium ore mining are not counted as radioactive waste, which is why these practices – as has already been the case in the national reports since the Second Review Meeting – are outlined in a separate report, which describes the state of ecological restoration in March 2017.

To justify this procedure, reference is made to the fact that according to § 118 StrlSchV [1A-8] pursuant to Article 9(2) in conjunction with Ann. II, Chapter XII, Section III nos. 2 and 3 of the Unification Treaty of 31 August 1990 [1A-4] individual regulations of the former German Democratic Republic (GDR) shall continue to apply in the new *Länder* to the ecological restoration of the legacies of past practices as well as to the decommissioning and ecological restoration of the operational installations and sites of uranium ore mining if any radioactive materials, especially the decay products of radon, are present. These regulations are:

- the Ordinance on Nuclear Safety and Radiation Protection (VOAS) of 11 October 1984 together with the implementing regulation, and
- the Order on Radiation Protection in Relation to Slag Heaps and Industrial Repositories and the Use of Materials Deposited there (HaldenAO).

Compared with other regulations on radioactive waste, both regulations allow a different treatment, taking into account the minor radioactivity and the special characteristics of the former Wismut workings and the current Wismut ecological restoration actions. In doing so, radiation protection is fully taken into consideration.

Such an approach is necessary as the StrlSchV can only be applied with restrictions or not at all to ecological restoration in the area of former mining activities. The VOAS is based in its radiation protection principles on the recommendations of the International Commission on Radiological Protection (ICRP 26 of 1977 and ICRP 32 of 1981). Regarding the classification of the materials generated at the uranium ore mining locations and other legacies (contaminated sites), it is necessary that the terminology and exemption limits of the above-mentioned regulations of the former GDR are used due to their continued application. In the case of heap materials and tailings as well as other waste materials at the Wismut sites and the contaminated sites of uranium ore mining, the generated waste is generally not radioactive waste according to the VOAS or the implementing regulation regarding the VOAS. More detailed technical explanations regarding these regulations were already provided in the report and the answers for the Second Review Meeting in 2006.

A national legal consideration of the residues from uranium ore mining and processing according to the regulations of the VOAS and the HaldenAO does not contradict the requirements or the purpose of the Joint Convention. What is essential for reaching the objectives of the Joint Convention (Chapter 1, Article 1(i) to (iii)) and their review is a transparent structure of the measures. This transparency is to be ensured by the respective national reports. In connection with its previous reports, Germany provided comprehensive information at the Review Meetings on the ecological restoration activities and the progress made; the intention is to keep doing so. The only difference to other views which hold that information in this respect is mandatory is that the accounts are given not as part of the National Report but rather in a separately annexed report. This approach does not, however, mean that those Contracting Parties which interpret the purpose of the Joint Convention differently from Germany are denied any information that they need for the mutual verification of whether the safety objectives formulated in the Joint Convention have been reached.

According to the Federal Office for Radiation Protection (BfS), the residues present at those sites amount to about $46.5 \cdot 10^6$ m³ of heaps and about $4.7 \cdot 10^6$ m³ of mill tailings. A register of radiologically relevant sites contaminated from mining activities has been established.

According to § 11(8) of the Precautionary Radiation Protection Act (StrlSchVG [1A-5]), the BfS was responsible for the determination of the environmental radioactivity originating from mining operation in the presence of natural radioactivity in the new Federal States. Therefore, the BfS carried out the project “Radiological Survey, Investigation and Assessment of Mining Residues

(*Altlastenkataster*)". Radioactive legacy sites of uranium mining no longer belonging to the Wismut GmbH and radioactive legacy sites from historical mining activities were systematically catalogued, explored and radiologically assessed. This comprised the following objects:

- Processing facilities (facilities for separation and processing of the usable material by mechanical, chemical or metallurgical processes, including the plant areas and associated premises),
- industrial settling ponds (basins for deposition of tailings and cleaning of liquid process media from processing facilities),
- heaps (stockpiles of excavation material from mining or mechanical ore processing or of residues of metallurgic processes (slags)),
- prospected sites (shallow outcrops on small areas for exploration of ores or raw materials),
- galleries (horizontal drifts),
- shafts (vertical drifts),
- open pits and cavities (not being backfilled),
- plants (unvegetated areas of facilities and possibly undecontaminated mining sites like ore bunkers, uranium ore box storage, hydro-engineering plants etc.) and ore loading facilities (areas not located on premises on which ore was reloaded).

Apart from these objects, the identification of sites influenced by mining operations in the vicinity of the objects listed above and for which measures for reduction or avoidance of exposure of the general public was of special interest. This project identified those sites for which exposure above 1 mSv/a could not be excluded and for which therefore further investigations and – if necessary – remedial actions or restrictions for use could be considered. The aim, execution and results of this project are summarised in [BfS 02].

In order to make efficient use of financial resources, the investigation was concentrated on potentially contaminated areas. The results of the investigations were stored in the A.LAS.KA database and in the technical information system on environmental radioactivity caused by mining and were also discussed extensively in area-specific reports. The data and information are available to the competent authorities of the *Länder* of Saxony, Saxony-Anhalt and Thuringia.

In parallel to the *"Altlastenkataster"* project, the BfS carried out a measurement programme to investigate the outdoor exposure by radon. The results showed that the radon concentration is markedly increased in the direct vicinity of mining sites compared to the natural background, but that there is no large-scale influence.

Remediation of contaminated Wismut sites in Saxony commenced in 2003 on the basis of an administrative agreement between the Federal Government and the *Land* of Saxony. In 2013, the basis for the continuation of remediation work at the Wismut sites in Saxony until 2022 was provided by a supplementary administrative agreement.

H.3 Article 13: Siting of proposed facilities

> ***Article 13: Siting of proposed facilities***
>
> *(1) Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed radioactive waste management facility*
>
> *i) to evaluate all relevant site-related factors likely to affect the safety of such a facility during its operating lifetime as well as that of a disposal facility after closure;*
>
> *ii) to evaluate the likely safety impact of such a facility on individuals, society and the environment, taking into account possible evolution of the site conditions of disposal facilities after closure;*
>
> *iii) to make information on the safety of such a facility available to members of the public;*
>
> *iv) to consult Contracting Parties in the vicinity of such a facility, insofar as they are likely to be affected by that facility, and provide them, upon their request, with general data relating to the facility to enable them to evaluate the likely safety impact of the facility upon their territory.*
>
> *(2) In so doing, each Contracting Party shall take the appropriate steps to ensure that such facilities shall not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 4.*

The siting process outlined in Article 13 refers to proposed radioactive waste management facilities and repositories. These types of facilities are addressed separately in the following two subsections. As the information required under Article 13(1) numbers (i) to (iv) has already been given in other sections of this report (see reporting on Article 6), the relevant information is merely summarised here and reference is made to the appropriate sections.

H.3.1 Siting of new facilities for radioactive waste management

For facilities for radioactive waste management which require a licence according to the Atomic Energy Act (AtG) [1A-3], the remarks provided for Article 6 apply accordingly.

For the other facilities for radioactive waste management, only the handling of radioactive substances requires a licence according to § 7 of the Radiation Protection Ordinance (StrlSchV) [1A-8], depending on the nature of the facility. In contrast to the facilities mentioned above, this licensing procedure is in principle not regulated by the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10]. An exception is the case where the respective use requires an environmental impact assessment (EIA) according to the requirements in the Environmental Impact Assessment Act (UVPG) [1B-14]. Regulations of the AtVfV are applied at least with respect to the EIA. Licensing is carried out by the competent licensing authority of each *Land* and follows the process described in the following.

The licensing requirements which must be met by such a facility are described in § 9(1) StrlSchV. With respect to the siting of such facilities, the following licensing requirements are particularly relevant:

- the necessary protection must be ensured against disruptive action or other interference by third parties,

- the choice of the site must not conflict with overriding public interests, particularly in view of its environmental impacts.

The required documentation and information depends on the type of facility and in particular on whether or not an EIA procedure is necessary. According to Appendix 1 of the UVPG [1B-14], an EIA is required for:

- 11.3: Construction and operation of a facility or installation for the handling or management of irradiated fuel assemblies or highly radioactive waste.

In addition, the following facilities or installations (see Appendix 1 of the UVPG) require a general preliminary assessment of each individual case according to § 3c(1) of the UVPG:

- 11.4: Construction and operation of a facility or installation for the storage, handling or treatment of radioactive waste where the activities reach or exceed those limits laid down in an ordinance promulgated on the basis of the AtG and compliance with such limits does not require any measures for mitigating the consequences of deviations from specified normal operation (according to § 50 StrlSchV, such activities are defined as 10^{07} times the exemption levels as specified in Appendix III, Table 1, column 2 of the StrlSchV in the case of unsealed sources and 10^{10} times the exemption levels as specified in Appendix III, Table 1, Column 2 of the StrlSchV in the case of sealed sources).

This general preliminary assessment includes a rough review of the individual case with respect to potential substantial negative environmental impacts, with due regard for the criteria listed in Appendix 2 of the UVPG (including characteristics of the project, site, possible effects). Based on the outcome of this preliminary assessment, the competent authority will determine whether or not an EIA is required.

Where the cases listed above pertain to the planned radioactive waste management facility or installation and if an EIA is required for the facilities or installations listed in point 11.4, the type of information outlined in the remarks on Article 6(1)(i) and Article 6(1)(ii) must be provided. This also implies the involvement of the general public (see reporting on Article 6(1)(iii)) as well as the participation of other authorities and, where applicable, the participation of authorities of other countries (see reporting on Article 6(1)(iv)).

The Nuclear Waste Management Commission (ESK) Guidelines for the storage of radioactive waste with negligible heat generation [4-3] summarise the requirements especially for storage facilities. For example, they describe, i.a., the preference of passive to active safety systems, the great importance of the casks for ensuring the protective functions compared with the storage building (which under normal specified operating conditions mostly only has the function of shielding against the environment and of weather protection of the stored radioactive waste and the storage facility's own technical installations), requirements for radiation monitoring inside the building and in the environment, structural requirements, protection systems, etc.

Asse II mine

A precondition for retrieval of the radioactive waste from the Asse II mine is a dedicated storage facility. Furthermore, conditioning of the radioactive waste is necessary for its storage and later disposal in a yet to be determined repository.

The preliminary planning for the storage facility has been completed. The completion of the concept design for the storage facility building, which has in part been started, depends on the site of the storage facility. The Federal Office for Radiation Protection (BfS) has set up criteria for the selection of a storage facility site and discussed these with the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and the Asse II advisory group

(*Asse II-Begleitgruppe*). As a result, a report on the criteria [BfS 14] has been presented in January 2014. From the point of view of the operator (Bundes-Gesellschaft für Endlagerung mbH (BGE)), the first step should be to look for possible sites in the vicinity of the grounds of the mine. It should be possible to link the storage site with the grounds of the mine. Only if there is no suitable area close to the Asse II, the area for the repository site selection would be extended. The Asse II advisory group requires the inclusion of sites outside the region.

In connection with the repository site selection, the BfS presented two parameter studies on radiological impacts of a storage site and on the transportation required for it. To better justify the approach of the BfS (first to consider the vicinity of Asse II), it was agreed to investigate the direct radiation from the plant resulting from the storage facility during normal operation at varying distances to residential areas within the scope of a parameter study. In addition, the direct radiation should be compared with radiation exposures resulting from waste transport to storage facility sites which are further away from Asse II. Incident analyses as well as the effects of the exhaust air during operation were not subject of this parameter study; these are only feasible based on concrete site data. As the aspects incident analysis and the effect of the exhaust air were explicitly desired during the advisory process, these issues were incorporated into a second parameter study based on data of a real but anonymous site.

The results of both parameter studies were presented to the advisory group und published by the BfS. A working group on the repository site selection procedure was established. The group started its work, first step of which will be the identification of the potentially available areas for the site comparison. After that, the repository site selection procedure will be started in accordance with the report on the criteria agreed.

Current planning provides for the storage facility building and the conditioning plant to be completed and ready for accepting waste by the year 2031.

§ 57b AtG (“Lex Asse”) [1A-26], which was amended in 2013, offers the possibility of combining several procedural steps of the EIA if expedient.

H.3.2 Siting of disposal facilities

Repository for heat-generating radioactive waste

Regarding the search for a repository for heat-generating radioactive waste, consensus across the political parties was achieved when in July 2013 the Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste (Repository Site Selection Act – StandAG) [1A-7a] was adopted.

Prior to the start of the repository site selection procedure, the Commission on Storage of High-Level Radioactive Waste has considered and assessed basic issues relevant for the repository site selection procedure. Furthermore, the Commission has evaluated the StandAG and made recommendations for its further development. The *Bundestag* and the *Bundesrat* have reviewed these recommendations and considered them in the Act on the Reorganisation of the Organisational Structure in the Field of Disposal [1A-30] as well as in the Act Amending the Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste [1A-7b] which largely entered into force on 16 May 2017 (see Chapter E.2.2 for details on the Act on the Reorganisation of the Organisational Structure in the Field of Disposal as well as on the StandAG).

The supervisory authority for the implementation of the repository site selection procedure is the Federal Office for the Safety of Nuclear Waste Management (BfE), already founded in 2014 which is currently being developed. Apart from the supervision of the implementation of the procedure, BfE’s essential tasks are reviewing reports of the project implementer, specifying the site-specific exploration programmes and assessment criteria for the repository site selection procedure as well as public information and participation. Furthermore, according to § 23d which was newly added to the AtG, the BfE is given the responsibility for the nuclear licensing of federal facilities for the storage and disposal of radioactive waste, which used to be the responsibility of the *Länder*. For the Konrad repository and the Morsleben repository for radioactive waste (ERAM), transitional provisions are laid down in § 58(6) and (7) AtG.

The BGE was assigned to perform the duties as the project implementer with effect from 25 April 2017. The BGE is responsible for the implementation of the repository site selection procedure according to mandatory requirements. Repository site selection, construction, operation and decommissioning of the repositories are performed by the newly founded company. The company belongs to the public sector and has entrepreneurial freedom of action.

The repository site selection procedure is divided into three phases:

- In the first phase, on the basis of the whole German territory and the identified presence of potential host rock, geo-scientific exclusion criteria and minimum requirements are applied. Subsequently, subareas with particularly favourable geological conditions are selected by applying geological weighing criteria. Within these subareas, site regions for surface exploration are selected by further refinement and by applying scientific planning criteria as well as on the basis of results of preliminary representative safety analyses. The *Bundestag* and the *Bundesrat* decide on the proposal by law.
- In the second phase, the surface exploration of the selected site regions is carried out. The exploration results are incorporated in refined preliminary safety investigations and the site regions are compared again according to exclusion criteria, minimum requirements and weighing criteria agreed. The result is a list of sites which are subject to underground exploration. This proposal, too, is submitted to the *Bundestag* and the *Bundesrat* for decision by law.
- In the third phase, the underground exploration of the selected sites is carried out. Comprehensive preliminary safety investigations and comparative analyses of the remaining potential sites aim at selecting the site that ensures the best possible safety for a period of one million years. This phase is completed with the determination of the site by the German *Bundestag* and the *Bundesrat.* After this final, legally defined decision on the site, the BGE acts as the applicant in the nuclear licensing procedure, conducted by the BfE as a licensing authority.

All phases of the repository site selection procedure are to be accompanied by intensive public involvement and participation. The BfE is responsible for the public participation in the repository site selection procedure. The BGE, as the project implementer, will inform about its measures taken within the frame of the repository site selection procedure. As the social authority, a “national advisory committee” was established at national level in November 2016. At the level of the regions concerned, the so-called regional conferences will be institutionalised. They should be provided with necessary appropriations to be able to accompany the repository site selection procedure critically and constructively by involving independent expertise. A council of the regions will improve networking of the regions concerned by the repository site selection procedure including communities of the existing storage facilities for high level radioactive waste and spent fuel, already concerned by the future disposal issue.

Repository for radioactive waste with negligible heat generation – Konrad repository

The Konrad mine was plan-approved as a repository for radioactive waste with negligible heat generation and affirmed in 2007 by the administrative court. Thus, the repository site selection is concluded, the repository is being erected.

Repository for radioactive waste with negligible heat generation which cannot be disposed of in the Konrad repository

In the National Programme (NaPro) [BMUB 15] and in the discussion paper of the ESK [4-23] relating to it, the types and roughly estimated amounts of radioactive waste with negligible heat generation which cannot be disposed of in the Konrad repository are specified in the following:

- in case that there will be no further reutilisation, the expected waste package volume of waste resulting from uranium enrichment is approx. 10,000 m³ of depleted uranium,
- waste to be retrieved from the Asse II mine (approx. 220,000 m³),
- other waste that will not be emplaced in the Konrad repository.

These additional waste cannot yet be quantified in detail, in particular because neither data on the reuse of residuals from uranium enrichment, nor the operating time of the uranium enrichment plant, nor the amounts of waste arising from waste retrieval from the Asse II mine nor the total amount of other waste not suitable for emplacement in the Konrad repository is finally determined.

According to the NaPro, the disposal of the above-mentioned radioactive waste with negligible heat generation and heat-generating waste at the same site is to be examined and considered within the framework of the repository site selection procedure. The ESK made clear in its recommendations that such an option would be conceivable under the exclusion of cross-interference of both waste types. Nevertheless, in the currently starting repository site selection procedure, priority is given to the realisation of a repository for heat-generating radioactive waste. Additional storage of radioactive waste with negligible heat generation at the same site must not lead to a safety level reduction for heat-generating radioactive waste or to an exclusion of sites due to the insufficient area size for radioactive waste with negligible heat generation. If no site is identified in the repository site selection procedure where both types of waste can be disposed of safely, another site is to be found for radioactive waste with negligible heat generation, as a consequence. For such a case, a standardised procedure is not yet determined.

H.3.3 Research activities and international cooperation in the field of disposal

The general programmatic fundamentals as well as the research objectives and promotion areas in the field of disposal are formulated in the 6th Energy Research Programme of the Federal Government, "Research for an environmentally sound, reliable and affordable energy supply". The ministry in charge of the fundamental, site-independent waste management research is the Federal Ministry for Economic Affairs and Energy (BMWi).

Apart from the scientific and technical gain, the research that is carried out contributes to the continual development of the state of the art in science and technology and hence to the fulfilment of the stringent requirements of, i.a., the AtG for the safe management of radioactive waste and spent fuel. Furthermore, the research activities contribute substantially to the development and maintenance of scientific and technical competence and promotion of young researchers in the field of radioactive waste management.

A significant contribution to the waste management research and, especially, to the repository research and to the international cooperation is made by the German Association of Repository Research (DAEF) founded on 16 January 2013. The aim of the DAEF is the further development and expansion of cooperation of its members and the use of their cumulative expertise in the field of repository research. The DAEF offers scientific and technical advice to the Federal Government and its authorised Federal and *Land* authorities as well as to the *Bundestag* and other interested institutions. Currently, research institutions, large-scale research institutions and universities focusing on the repository research are members of the DAEF.

Although defined as a national task, serious efforts are undertaken worldwide across national borders to consider the disposal of radioactive waste as a multinational task guided by safety aspects that has to be tackled jointly at an international level. Hence, international cooperation is seen as an important element of the activities relating to the waste management research as it opens up the possibility of making use of the expertise of all cooperation partners involved and of exploiting all associated synergies, allowing the financial burdens to be shared, and contributing to solving the task effectively in each national context.

For more than three decades, German scientists have been involved in international research projects on waste management and repository research with the aim to build up and expand experience and knowledge, as well as to obtain the necessary expertise in connection with the application and use of methods and technologies. As, on the one hand, there is no underground laboratory in Germany anymore but on the other hand, there is the need to carry out specific studies and experiments under realistic conditions, cooperation – especially in underground laboratories (Mt. Terri (CH), Grimsel (CH), Äspö (S), Bure (F)) – and the participation in demonstration projects is of great importance and has to be considered indispensable. This cooperation has not only substantially developed further the state of knowledge on clay stone and crystalline rock in Germany; it has also created the basis for assessing non-saline host rock types. Furthermore, thanks to these research activities, it has been possible to build up and expand considerable knowledge in German organisations, allowing well-founded evaluations and assessments of repository concepts in all host rock types. This has contributed to the fact that the political call for an analysis and assessment of all relevant host rock types in Germany could be followed.

The research activities that lie within the responsibility of the BMWi and are carried out by German research institutions as part of international cooperations are for the most part performed within the framework of bilateral agreements with repository organisations, by way of project-funded participation in consortia, in European Union (EU) projects, and as part of direct contractual agreements and work within the framework of scientific and technical cooperation.

Cooperation takes place predominantly with organisations from other European countries and – at varying intensity – with the United States of America, the Russian Federation, and China.

Within the framework of the international cooperation activities, projects with German participation were carried out nationally, as well as within the framework of EU research framework programmes (7th EU Research Framework Programme and HORIZON 2020).

Within the framework of the cooperation with the OECD/NEA, activities include work in the Integration Group for the Safety Case (IGSC) and in the Working Group on the Characterisation, the Understanding and the Performance of Argillaceous Rocks as Repository Host Formations (CLAY CLUB), in the Expert Group on Repositories in Rock Salt Formations (SALT CLUB), in the Expert Group on Repositories in Crystalline Formations (CRYSTALLINE CLUB) as well as in the Expert Group on Operational Safety (EGOS).

Activities in connection with the "Implementing Geological Disposal of Radioactive Waste – Technology Platform" (IGD-TP) (www.IGDTP.eu) take place in a special context of international cooperation.

H.4 Article 14: Design and construction of facilities

> ***Article 14: Design and construction of facilities***
>
> *Each Contracting Party shall take the appropriate steps to ensure that*
>
> *i) the design and construction of a radioactive waste management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases;*
>
> *ii) at the design stage, conceptual plans and, as necessary, technical provisions for the decommissioning of a radioactive waste management facility other than a disposal facility are taken into account;*
>
> *iii) the design stage, technical provisions for the closure of a disposal facility are prepared;*
>
> *iv) the technologies incorporated in the design and construction of a radioactive waste management facility are supported by experience, testing or analysis.*

H.4.1 Impacts on individuals and the environment

Regarding the design and construction of radioactive waste management facilities, both the requirements of relevant acts and ordinances (such as the Atomic Energy Act (AtG) [1A-3] and the Radiation Protection Ordinance (StrlSchV) [1A-8]), and the content and recommendations of non-mandatory guidance instruments are duly taken into account and applied with regard to radiological aspects (e.g. KTA 1301.1; see Safety Standards of the Nuclear Safety Standards Commission (KTA) in Annex L-(d)).

The realisation of these requirements creates the prerequisites for compliance with the radiation exposure limits for persons who are exposed to radiation by virtue of their occupation, as well as for the population in the surrounding area during operation of the facility, as stipulated in the StrlSchV.

Radiological protection of the personnel

The measures to ensure the radiological protection of operating personnel which must be taken into account during the design and construction of facilities for the management of radioactive waste refer, in particular, to structural measures regarding the arrangement and design of the rooms in the controlled area of the facility. In this respect, the emphasis is on the arrangement and accessibility of the rooms, the arrangement and accessibility of the waste packages, the design of the walls from the point of view of shielding, the possibility to decontaminate wall and floor surfaces, and the space requirement for tasks related to radiation protection, as well as the design of the entry and exit of the controlled area (including facilities for issuing work and protective clothing, washing facilities for the personnel, and facilities for contamination control before leaving the controlled area). The system design and the ventilation concept, the storage concept, the measurement methods for radiation protection monitoring within the controlled area of the facility (local dose rate, air activity concentration, surface contamination) and monitoring of the internal and external radiation exposure of personnel are additional aspects which must be taken into account during the design and construction of facilities for the management of radioactive waste and in the licensing procedure by the competent authority.

Radiological protection of the population during specified normal operation

The radiological protection of the population during specified normal operation is ensured during the planning and construction of radioactive waste management facilities by their structural and technical design. In addition to the shielding effect of the walls of the controlled area already mentioned above under the aspect of radiological protection of operating personnel, which also serve to limit direct radiation at the site and in the vicinity of the facility in accordance with § 46 StrlSchV [1A-8], appropriate technical equipment must also be provided to limit the discharge of radioactive substances with air or water, in order to comply with the limits specified in § 47(1) StrlSchV for individual members of the local population in the vicinity of the facility. Such equipment comprises retention devices for airborne radioactive substances, as well as treatment facilities for contaminated waters and transfer tanks for waters from the controlled area. Moreover, the prerequisites for the measurement of discharges and their nuclide-specific balancing are ensured by means of corresponding measurement, sampling and analysis methods.

Radiological protection of the population in case of design basis accidents

In accordance with § 50 StrlSchV [1A-8], the conceptual planning of a radioactive waste management facility (storage facility, conditioning plant) includes structural and technical protective measures, with due regard for the potential extent of any damages, to limit radiation exposure caused by the release of radioactive substances into the environment in case of a design basis accident. The licensing authority defines nature and scope of the protective measures with reference to each individual case, particularly with regard to the hazard potential of the facility and the likelihood of a design basis accident occurring.

According to § 49 StrlSchV, the planning of structural or other technical protective measures against design basis accidents in or around a repository for radioactive waste must be based on a maximum effective dose of 50 mSv caused by the release of radioactive substances into the environment in the least favourable case. This requirement remains applicable until decommissioning. Individual dose limits are to be applied for specified organs. Further details can be found in Table F-1. The state of the art in science and technology is decisive for the adequacy of precautionary measures against design basis accidents.

At the same time, the measures to protect the population against radiation also serve to ensure the protection of the environment.

H.4.2 Planning concepts for decommissioning

The decommissioning of radioactive waste management facilities is taken into account already at the design stage and during their construction, with the analogous application of the stipulations and recommendations contained in the statutory rules and regulations and non-mandatory guidance instruments on the decommissioning of nuclear facilities (see [3-73]). With regard to facilities for the dry storage of high level waste (HLW) casks, guidelines [4-2] must also be applied. These guidelines state that a storage facility must be designed and constructed in such a way that it can either be decommissioned or reused or removed in compliance with the radiological protection regulations.

Regarding the planning and construction of radioactive waste management facilities, the design ensures that the decommissioning of these facilities at a later stage takes place with due regard for the radiological protection of operating personnel and adherence to the radiological protection regulations. In particular, structural prerequisites must be generated in order to ensure the use of specific decontamination and dismantling methods, including remote-controlled methods, during the subsequent decommissioning of the facility.

For this reason, a corresponding concept for decommissioning must already be available at the design and construction stage of the facility. This concept includes specifications regarding the intended decommissioning option, which depends primarily on whether the radioactive waste management facility is constructed as part of a major nuclear facility, thus being integrated into the decommissioning procedure of this facility, or whether it constitutes a separate site, thus entailing an independent decommissioning procedure, directly related to this facility. Further decisive parameters of the decommissioning concept are determined by the composition of the radioactive waste treated at the facility, in particular by whether or not it involves waste containing fissile material.

Within the context of the decommissioning concept, the operator plans the decommissioning procedure, assuming that any residual quantities of the radioactive waste treated at the facility have been removed beforehand. The decommissioning concept also incorporates the requirements with regard to decontamination and dismantling methods and thus the radiological protection of the personnel. Since activation by neutrons can be virtually excluded, these requirements result from the contamination of components. In this respect, however, it is important to consider that during treatment of waste containing fissile material or waste with other alpha-sources, contamination from alpha-emitting nuclides may also be present.

The requirements relating to the proposed decontamination methods take into account the minimisation of individual and collective doses to achieve a condition adequate for the performance of decommissioning and dismantling work, as well as the reduction of volume and the recovery of residues as harmlessly as possible, with due regard for the secondary waste generated.

The requirements relating to the dismantling methods depend on the technological task (material, size of the components, environmental conditions, accessibility), the radiation protection conditions (existing activity, potential for aerosol formation, risk of contamination, confinement of mobile activity, limitation of the individual and collective dose), and the intended subsequent treatment as a residue for reuse, conventional disposal, or disposal as radioactive waste.

The decommissioning of the Karlsruhe Vitrification Plant (VEK), for example, will primarily be performed using the equipment required for operation, which was already considered in the design of the facility. The planned steps and measures for decommissioning of the facility were described by the applicant in his safety case.

H.4.3 Closure of a repository

Upon termination of the operational phase, a repository in deep geological formations must be safely sealed against the biosphere in the long term. Here, it has to be considered that the emplacement of the waste packages will be back to front, which means that depending on the emplacement technique chosen, the emplacement fields consisting of boreholes, chambers or drifts will be filled with waste packages, the remaining cavities backfilled and, if necessary, sealed with dam structures, and the emplacement field subsequently abandoned. This way, a repository in deep geological formations will already be successively closed during the operational phase. Once all waste packages have been emplaced, the closure phase will ensue in which all measures and precautions are taken above and below ground that are necessary for the final closure of the repository. The closure proper will then consist of the backfilling of the drifts and cavities that are still open below ground and the backfilling of the shafts.

As a licensing prerequisite, § 9b(4) At in conjunction with § 7(2)(3) [1A-3] stipulates that "the necessary precautions have been taken in the light of the state of the art in science and technology to prevent damage resulting from the construction and operation of the installation".

The Commission on Radiological Protection (SSK) recommendation of 15 December 2010 on the Morsleben repository for radioactive waste (ERAM) states that the potential radiological exposure in the post-closure phase should not exceed an individual effective dose of 0.1 mSv/a in the case of probable events and processes and of 1 mSv/a in the case of less probable events and processes [4-11b]. In order to take the existing situation and the only limited plannability of the closure of the repository into account, however, these values should not represent limit or reference values but are to be understood as guide values in terms of the International Commission on Radiological Protection (ICRP), which here are also used for radiation exposure levels in the remote future.

According to the safety requirements [BMU 10], it is to be demonstrated for a repository for heat-generating radioactive waste to be constructed that an additional effective dose in the range of 10 µSv/a in the case of probable events and processes and of 0.1 mSv/a in the case of less probable events and processes will not be exceeded in the post-closure phase.

Due to requirements in other legal areas, it is necessary to ensure that detrimental environmental impacts are avoided or limited to the bare minimum. Mining law requires that there must be no long-term subsidence on the surface which could have inadmissible consequences for protected commodities. Water legislation stipulates that there must be no reason to fear harmful pollution of groundwater or any other detrimental change to its characteristics.

In order to meet the aforementioned requirements, it is necessary to take into account the respective situation of the repository, such as the natural (geological) and any technical barriers which may be required, the rock-mechanic characteristics of the host rock (such as convergence), the waste inventory, the emplacement technique and the construction materials for backfilling and closing the repository. With the aid of a comprehensive site-specific long-term safety analysis on the basis of a complete scenario analysis and the intended backfilling and closure concept, it is necessary to demonstrate that the closure measures avoid any inadmissible effects caused by the release of radioactive material and non-radioactive hazardous chemical components of the waste packages and construction materials, as well as subsidence on the surface.

For this reason, a plan approval procedure for a repository must include a closure concept as the basis for its long-term safety case. The measures to be taken upon the cessation of emplacement operations are specified. The nature and manner of its execution are subject to the supervision of the competent authority.

H.4.4 Technologies used

There is no difference between the requirements governing the technologies applied to the design and construction of radioactive waste management facilities and those for facilities for the management of spent fuel. As such, the remarks on Article 7(iii) apply in full to Article 14(iv).

H.5 Article 15: Assessment of the safety of facilities

> ***Article 15: Assessment of the safety of facilities***
>
> *Each Contracting Party shall take the appropriate steps to ensure that*
>
> *i) before construction of a radioactive waste management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its operating lifetime shall be carried out;*
>
> *ii) in addition, before construction of a disposal facility, a systematic safety assessment and an environmental assessment for the period following closure shall be carried out and the results evaluated against the criteria established by the regulatory body;*
>
> *iii) before the operation of a radioactive waste management facility, updated and detailed versions of the safety assessment and of the environmental assessment shall be prepared when deemed necessary to complement the assessments referred to in paragraph (i).*

H.5.1 Assessment of the safety of facilities before construction of radioactive waste management facilities

Assessment of the safety of radioactive waste management facilities (storage facilities for radioactive waste, conditioning facilities and repositories), and the assessment of environmental impacts prior to construction of such a facility, are carried out as part of a licensing procedure (see reporting on Article 19). An assessment of the safety and of the environmental effects prior to commissioning takes place within the framework of the accompanying nuclear regulatory supervision (see Chapter H.5.3 for details).

Regulatory basis

Under § 7 of the Radiation Protection Ordinance (StrlSchV) [1A-8], the handling of radioactive materials in nuclear facilities for the management of radioactive waste requires a licence.

A special case is the construction of a vitrification facility in accordance with § 7 of the Atomic Energy Act (AtG) [1A-3], since apart from the processing of high level waste, nuclear fuels will also be treated or processed in such facilities. The essential features of the safety assessment in the licensing procedure pursuant to § 7 AtG are outlined in the remarks on Article 8, and apply mutatis mutandis to the licensing procedure for facilities for the vitrification of highly radioactive waste.

Whereas the licence pursuant to § 7 AtG combines the licences required for the construction and operation of the nuclear facility and for the handling of nuclear fuels (see reporting on Article 8), § 7 StrlSchV regulates only the handling of radioactive materials. A building permit under the applicable building law must also be applied for. Repositories for radioactive waste are subject to authorisation under § 9b AtG.

Applications for licences under the Atomic Energy Act must be submitted to the competent authority of the respective *Land* (for repositories at the Federal Office for the Safety of Nuclear Waste Management (BfE). The application must outline the extent to which the nuclear facility possesses the required safety characteristics, and conforms to the specifications of the applicable rules and regulations. In the licensing procedure under § 7 StrlSchV, the documents listed in Appendix II, Part A, of that ordinance must be enclosed with the licence application.

The preconditions for a licence for handling radioactive materials are governed by § 9 StrlSchV. They are described in detail in the remarks on Article 19.

Regulatory review

Among other things, one licensing condition is that on handling radioactive waste, the equipment must be available and the measures must be taken in accordance with the state of the art in science and technology to ensure that the protective provisions are observed (§ 9 StrlSchV [1A-8]). The standards of the Nuclear Safety Standards Commission (KTA) and the German Standards Institute & German Association of Electrical Engineers (DIN/VDE) are used as the basis for checking the licensing requirements, and are applied mutatis mutandis. During the course of verifying the licensing requirements, the competent licensing authority may call upon the services of independent experts under § 20 AtG [1A-3].

According to the Environmental Impact Assessment Act (UVPG) [1B-14], an environmental impact assessment (EIA) is mandatory for nuclear facilities designed to store radioactive waste for more than ten years at a location other than that where they were generated, and for nuclear facilities requiring a licence under § 7 AtG. For facilities which provide for the storage of radioactive waste for less than ten years, a basic requirement of performing an EIA is not defined. However, it also applies to facilities that do not require an EIA that all radiological effects have to be examined within the framework of the safety assessments of the licensing procedure. More information on the EIA can be found in the remarks on Article 13 and Article 6.

In addition, the UVPG provides for general screening of individual cases in the case of nuclear facilities for the storage, handling, or processing of radioactive waste whose activity inventories reach or exceed the values specified in § 53 StrlSchV (see Chapter F.5.1 for details). For such facilities, an EIA must be performed if the competent authority feels that the project may have substantial adverse environmental impacts.

According to § 12b AtG, the competent authorities are required to investigate the reliability of the persons responsible for the handling of radioactive materials, in accordance with the Reliability Assessment Ordinance (AtZüV) [1A-19], so as to safeguard against unauthorised actions that might lead to a misappropriation or substantial release of radioactive materials.

Requirements for design and operation

The requirements for the design and operation of facilities for the management of radioactive waste are shown by the example of the requirements for storage facilities.

In 2002, the Reactor Safety Commission (RSK) prepared safety requirements in particular for the storage of radioactive waste with negligible heat generation. These were last updated by the Nuclear Waste Management Commission (ESK) in February 2013 [4-3]. The criteria contained in them are used to assess the safety of a facility for the storage of radioactive waste as well as its effects on the environment. As for facilities for the management of radioactive waste, these safety requirements have to be applied at least to their storage areas and in analogy to the areas where processing takes place.

Facilities for the storage of radioactive waste are generally designed for the handling and storage of radioactive materials in waste packages. The waste containers thus assume the function of the safe activity confinement for the entire storage period. It is also admissible to design the storage facility with a view to handling radioactive waste that may cause emissions of radioactive substances, but this requires additional technical efforts with regard to the assumed airborne and liquid releases of radioactive substances.

According to [4-3], among others the following requirements for the waste products and packages have to be fulfilled in the storage of radioactive waste with negligible heat generation:

- Over the storage period until disposal, the waste products and waste containers have to be sufficiently chemically/physically stable. By conditioning radioactive waste for storage or disposal, it has to be ensured that the waste package properties relevant in connection with storage and disposal are maintained over the storage period.
- Changes in the waste product properties and the waste container properties (e.g. shrinking in the case of cement products, reactions between residues of organic solvents and coating materials on the inner container wall, gas formation and corrosion) have to be minimised.
- The origin and characteristics of the raw waste have to be recorded and documented. The waste products generated according to qualified procedures and possible interim products have to be assessed with regard to their suitability for long-term storage. Requirements regarding the data to be documented are specified in Appendix X of the StrlSchV. Access to and legibility of the documentation has to be guaranteed until the waste is emplaced in a repository or released according to § 29 StrlSchV [1A-8].
- In view of the principles of radiation protection, especially the ALARA principle, handling and surveillance measures within the storage area requiring the presence of staff are to be kept at a minimum.

To demonstrate that the requirements for storage are fulfilled, it is also possible to present the verifications that have been provided as part of a qualified procedure regarding the conditioning of the waste in compliance with the requirements of a repository.

The requirements for the waste containers and the large components that may have to be stored result in particular from the safety analyses and are specified in the technical acceptance criteria of the storage facilities. Moreover, the requirements of the traffic regulations according to the respective applicable dangerous goods regulations also have to be observed. Permission for storage is given by the respective competent authority.

Among others, the following requirements for waste containers ensue from the ESK recommendation [4-3]:

- The design of the waste containers has to be such that their handling can also be ensured during and after storage. The long-term integrity has to be ensured by means of an adequate design of the waste containers (e.g. corrosion protection, thick container walls). Possible impairments of the container integrity caused by impacts from the interior of the container (characteristics of the waste product) and from the outside (e.g. atmospheric conditions of the storage facility) have to be considered. Analogous considerations apply to the storage of large components.
- If the waste containers or large components are not suitable for long-term storage without any doubt due to their design, recurrent controls by non-destructive tests (e.g. visual inspections) shall be performed. To enable these controls, accessibility has to be ensured in the storage facility (e.g. by providing alleys between the package stacks or separate storage of packages). The scope of the controls shall be defined individually.

Accident analysis

The ESK recommendation [4-3] contains, among others, requirements for structural and technical installations in order to limit the effects of accidents. The physical structures are to be built according to the respective building codes of the *Länder* and according to the generally recognised engineering rules. Furthermore, the following applies:

- Regarding the protection against safety-relevant events in storage facilities, measures have to be taken upon the planning of structural or other technical protective provisions to limit the release of radioactive materials into the environment in the event of an incident. Here, §§ 49 and 50 StrlSchV in connection with § 117(16) StrlSchV [1A-8] have to be observed.
- Within the framework of an accident analysis it has to be examined which operational disturbances and incidents may occur during the storage of radioactive waste with negligible heat generation. On the basis of this analysis, the design basis accidents for storage are to be derived. Human errors shall be considered in the analysis. The following facility-internal events (internal impacts) are generally to be considered as design basis accidents:
  - mechanical impacts (drop of a waste package or drop of a load onto a waste package),
  - thermal impacts,
  - failures of safety-relevant systems and equipment (power supply, instrumentation and control installations, hoisting gear, transport vehicles).

  Also, the following external hazards have to be taken into account in the analysis of potential impacts, with special site-specific features and possible interactions with neighbouring nuclear power plants having to be taken into account:
  - natural external hazards, e.g. storm, rain, snowfall, freeze, lightning, flooding, earthquakes, landslides,
  - human-induced external hazards, e.g. impacts of harmful substances, blast waves caused by chemical reactions, external fires spreading to the interior, damage by mines caving, aircraft crashes.

Adaptation during operation

The terms of validity of the licences for the storage of radioactive waste with negligible heat generation are set differently from one authority to the other; they span several years up to unlimited periods. In order to allow an adaptation to the state of the art in science and technology or the rectification of deficiencies, the competent authority may impose additional licensing requirements.

H.5.2 Assessment of safety before construction of a disposal facility

Assessment of post-closure safety before construction of a disposal facility

§ 9b as well as § 7(2)(3) AtG [1A-3] stipulate that the necessary precautions must be taken according to the state of the art in science and technology to prevent damage from ionising radiation. These precautions are also pertinent to the period following closure of a repository. As the disposal of radioactive waste in Germany is defined as the maintenance-free, safe emplacement of these materials for an unlimited period of time, the long-term safety assessment is of particular importance within the licensing procedure.

Radiological verification of compliance with the dose limits may be provided in the form of model calculations. These calculations are used to determine and quantify potential releases of radionuclides from the repository through the geosphere into the biosphere and to calculate the possible radiation exposure of humans using a variety of exposure scenarios and model assumptions. The input data for these models is derived from the characteristic data of the radioactive waste, a description of the deposition and technical barrier concept, and the geological data of the model area obtained from a site exploration. The dose is calculated by means of suitable radio-ecological models.

The state of the art in science and technology is decisive when specifying a forecasting period for the required precautionary measures (isolation period). In other words, all relevant scientific and technological knowledge and experience must be taken into account. With the aid of a geoscientific long-term forecast, an isolation potential of > 10^{05} years has been calculated for the Konrad repository as a repository for radioactive waste with negligible heat generation.

Chapter 7.2 of the “Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste” [BMU 10] stipulates the following:

> „[...] Prior to any major decision pursuant to Chapter 5.1, a comprehensive, site-specific safety analysis and safety assessment covering a period of one million years must be carried out. [...] In particular, this assessment and the documentation thereof should include the following points:
>
> - the underlying final repository concept
> - the quality-assured collation of data and information from site exploration, research and development
> - the quality-assured implementability of requirements pertaining to technical barriers
> - the identification, characterisation and modelling of safety-relevant processes, together with confidence-building in this regard and qualification of the models
> - the comprehensive identification and analysis of safety-relevant scenarios and their allocation to probability categories pursuant to Chapter 6
> - the representation and implementation of a systematic strategy for the identification, evaluation and handling of uncertainties.”

On this basis, a long-term integrity of the containment-providing rock zone has to be demonstrated, a long-term radiological statement has to be prepared, and the robustness of technical components of the repository system and the exclusion of criticality have to be demonstrated.

The integrity demonstration also contains the verification that the pore water in the containment-providing rock zone does not participate in the hydrogeological cycle in terms of the Federal Water Act and that the protection goals of said Act are adhered to.

Assessment of impacts on the environment

§ 9b AtG [1A-3] stipulates that a plan approval procedure is mandatory for repositories for radioactive waste. The plan approval decision may only be granted if the prerequisites listed in the aforementioned section of the AtG have been met by the applicant (see reporting on Article 11(i) to (iv)). This also includes consideration of the common good and other provisions of public law, particularly with respect to the environmental impacts.

The Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10] and the Administrative Procedures Act regulate the design and implementation of the plan approval procedure. In addition, the UVPG [1B-14] requires the performance of an environmental impact assessment (EIA).

Stipulating that the state of the art in science and technology is a prerequisite for the plan approval decision ensures that the safety assessments and the environmental impact assessment are up-to-date at the time of issuing the plan approval decision.

In the cases where siting was determined by federal law, a licensing procedure substitutes the plan approval procedure. This currently applies exclusively to the site for a repository for heat-generating radioactive waste selected according to Repository Site Selection Act (StandAG) [1A-7a]. The legitimacy of the project regarding all public interests affected by it will also be verified by the licence.

H.5.3 Assessment of safety before the operation of radioactive waste management facilities

Under § 19 AtG [1A-3], the handling of radioactive substances is subject to government supervision. An assessment of the safety and the environmental impacts prior to commissioning of the nuclear facility occurs within the context of supervision which accompanies construction under the Atomic Energy Act.

If major deviations in the handling as specified in the licensing documents occur between the time of licensing until the commissioning of a facility for the management of radioactive waste, licensing under § 7 StrlSchV [1A-8] or § 7 AtG is required. Modification licences are applied for by the operator of the facility affected, sometimes within the framework of a nuclear regulatory authority order, at the competent licensing authority. The documents to be submitted together with the licence application have to reflect the state of the art in science and technology regarding the scope of effects of the part to be modified. The safety assessment carried out by the authority also has to be based on the state of the art in science and technology. Where applicable, in the case of projects requiring an environmental impact assessment under § 3e UVPG [1B-14], the assessment of environmental impacts must be repeated, e.g. if the alteration applied for could entail substantially altered impacts on the environment. In such a case, public participation is again necessary as part of the environmental impact assessment.

H.5.4 Stress test

The earthquake off the Japanese coast on 11 March 2011 and the resulting inundation by a tsunami triggered a nuclear disaster at the site of the Fukushima Nuclear Power Plant. Even if the initiating events of the nuclear disaster in Japan, especially the intensity of the earthquake and the height of the flood wave cannot be directly applied to European and German conditions, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU, today BMUB) deemed it necessary not only to carry out a robustness assessment of the German nuclear power plants and research reactors but also a stress test for the facilities for the management of irradiated fuel and radioactive waste in Germany as well as for the uranium enrichment plant at Gronau and the fuel fabrication plant at Lingen. The ESK was tasked with developing corresponding examination concepts for these facilities. The results of this stress test are documented in two ESK statements [4-11], see Chapter G.5.3 for details.

H.6 Article 16: Operation of facilities

> ***Article 16: Operation of facilities***
>
> *Each Contracting Party shall take the appropriate steps to ensure that*
>
> *i) the licence to operate a radioactive waste management facility is based upon appropriate assessments as specified in Article 15 and is conditional on the completion of a commissioning programme demonstrating that the facility, as constructed, is consistent with design and safety requirements;*
>
> *ii) operational limits and conditions, derived from tests, operational experience and the assessments as specified in Article 15 are defined and revised as necessary;*
>
> *iii) operation, maintenance, monitoring, inspection and testing of a radioactive waste management facility are conducted in accordance with established procedures. For a disposal facility the results thus obtained shall be used to verify and to review the validity of assumptions made and to update the assessments as specified in Article 15 for the period after closure;*
>
> *iv) engineering and technical support in all safety-related fields are available throughout the operating lifetime of a radioactive waste management facility;*
>
> *v) procedures for characterisation and segregation of radioactive waste are applied;*
>
> *vi) incidents significant to safety are reported in a timely manner by the holder of the licence to the regulatory body;*
>
> *vii) programmes to collect and analyse relevant operating experience are established and that the results are acted upon, where appropriate;*
>
> *viii) decommissioning plans for a radioactive waste management facility other than a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility, and are reviewed by the regulatory body;*
>
> *ix) plans for the closure of a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility and are reviewed by the regulatory body.*

H.6.1 Licensing of operation

Before commencing operation, all systems and equipment are subjected to commissioning tests in accordance with the Guidelines for the storage of radioactive waste with negligible heat generation [4-3]. These tests are specified as part of the licensing documents in a commissioning programme which ensures that the safety requirements outlined in Article 15 are met. The commissioning programme is subject to approval by the competent authority. The tests serve to demonstrate that the systems and equipment for the intended operation are in accordance with the conditions of their licences and can be operated as specified. The results are documented and assessed.

The overall operation must be suitably structured to ensure the safe performance of the operational processes. In particular, the administrative prerequisites regarding personnel, organisation and safety must be fulfilled. The competent authority supervises compliance with these prerequisites. Clear instructions must be drawn up in the form of an operating manual for operational processes, accident management and the removal of the consequences of incidents and accidents. Competencies and responsibilities must be clearly defined. The competent authority supervises compliance with these requirements.

Prior to initial emplacement or treatment of waste, the entire handling procedure, including the radiation protection measures, is tested. During the course of testing, any potential deficiencies in the procedure are identified. In this way, optimisations can be tested prior to handling the waste packages, and the envisaged procedures provided can be adapted and finalised.

In principle, the same procedure applies to conditioning plants.

H.6.2 Specification and revision of operational dose reference levels

All operational processes and the measures to be taken in case of an incident or accident are outlined in an operating manual, or in the case of a repository, in a mine book/operating manual, in form of clear operating instructions. These pay particular attention to all aspects affecting safety and define operational dose reference levels. The operational dose reference levels are defined on the basis of the Atomic Energy Act (AtG) [1A-3] in compliance with the corresponding stipulations of the Radiation Protection Ordinance (StrlSchV) [1A-8]. Here, the fundamental protection goals, such as the safe enclosure of activity and the guarantee of decay heat removal, have to be achieved both during normal operation and under corresponding accident conditions. In the licensing of operational discharge levels, the imperative of limitation of radiation exposure is applied by providing measures that are as reasonable as achievable. Furthermore, the procedure in case of modification or supplementation of components and processes must also be specified. The operating manual forms part of the licensing documents and is therefore subject to examination. This ensures that operatives are able to initiate and perform the necessary measures swiftly and competently in case of normal operation or incidents. This procedure is subject to regulatory supervision.

H.6.3 Compliance with established values

Regulatory supervision ensures observance of the procedures on operation, maintenance, monitoring, inspection and testing established in the nuclear licensing procedure for a radioactive waste management facility (see Table L-5 to Table L-13) as well as the consideration of the Guidelines for the storage of radioactive waste with negligible heat generation [4-3].

For the treatment of radioactive waste, conditioning techniques are used that are subjected to qualification, formerly by the Federal Office for Radiation Protection (BfS) and today by the Bundes-Gesellschaft für Endlagerung mbH (BGE) or the conditioned waste is subjected to product control procedures to ensure its suitability for disposal (reporting on Article 23 “Quality Assurance”).

Execution provisions are established for ensuring compliance with the acceptance criteria of storage facilities or the requirements for radioactive waste to be disposed of (waste acceptance criteria) respectively. These include operating instructions and test procedures which must be observed during handling of the packages.

Radioactive waste is subject to incoming inspection prior to any form of treatment or emplacement; this applies in particular for storage facilities and repositories. The incoming inspection serves the purpose of verification and must facilitate the following evidence:

- Identification control: The incoming inspection verifies whether the radioactive waste complies with its declaration for acceptance.
- Fulfilment of acceptance criteria of the storage facility/repository: The incoming inspection ensures that the acceptance criteria defined in the licence are fulfilled. For this purpose, reference may also be made to the quality-assured data of the conditioner.
- Verification of the data stated by the delivering party: The incoming inspection checks specific radioactive waste parameters independently from the data supplied by the delivering party. Specific parameters may include, for example, mass, dose rate and surface contamination.

As a general rule, the following aspects are controlled for the purposes of emplacement operation:

- mass, dose rate and surface contamination of the waste packages;
- condition and labelling of the waste packages;
- compliance with declared data.

Furthermore, the following is also observed:

- The incoming inspections are only performed by trained personnel.
- In the case of non-compliance, extended controls are performed.
- Any disturbances and findings are reported immediately.
- The emplacement is logged.

When removing waste from the storage facility, exit inspections are performed. Waste packages leaving the facility are subject to unequivocal identification. In addition, the removal of waste is also logged.

All the systems and equipment of the facility requiring testing or maintenance must be readily accessible or made accessible by technical means. The spatial conditions are designed in such a way as to allow sufficient space for maintenance work, and any additional shielding required for radiological protection reasons must be kept available. Regulations governing the preparation and performance of maintenance work are included in the operating manual.

At the site of the storage facility, the management facility or the repository, adequate numbers of qualified personnel are employed to ensure fulfilment of all safety requirements; these personnel must be subject to regular training. With regard to said personnel, a distinction is made between the following cases:

- Facilities or installations that are associated with nuclear facilities which are either in operation or in the process of dismantling: in such cases, the personnel of the nuclear facility perform most functions.
- Facilities or installations with permanent staffing covered by own personnel: these facilities are regarded as being independent with regard to operation.
- Facilities or installations which do not require permanent staffing: the functions are restricted to deployment on demand in case of treatment, emplacement or removal operations, or to regular inspections. The demand is temporary and is generally covered by personnel who primarily perform other tasks.

The technical qualification required for the respective position is demonstrated in accordance with the requirements of the StrlSchV [1A-8] or separate regulations. The requirements concerning responsibility for nuclear safety issues are regulated by the AtG [1A-3] and the StrlSchV. The responsibilities and regulations on representation are defined unambiguously in the operating manual.

Due regard is given to the development and promotion of a pronounced safety culture. This is particularly applicable to facilities where personnel activities are required relatively seldom or where changing personnel are deployed for different tasks. With regard to long-term operation of the storage facilities, it is assumed that changes of personnel are required. In this respect, measures are taken to ensure that the required personnel resources are available in order to maintain a sustainable safety culture. This is achieved by long-term personnel planning and careful planning with regard to the maintenance of experience.

Different emergency procedures may be required, depending on the type of management or storage facility and the waste stored. Based on the possibilities for the release of radioactive substances from the storage facility, an on-site emergency preparedness plan is drawn up, coordinated and agreed, where applicable, with the emergency preparedness plans of neighbouring facilities and the competent local and regional authorities. Hard copies of the on-site emergency preparedness plan are always kept available at a permanently staffed location. Further copies are submitted to the neighbouring facilities, the competent authorities and safety bodies, where applicable.

H.6.4 Availability of technical support

Report has already been given on the measures to ensure engineering support during the facility's operating lifetime via the provision of adequate competent personnel in the comments on Article 22(i). The requirements for storage facilities ensue from the Guidelines for the storage of radioactive waste with negligible heat generation [4-3], which stipulate that irrespective of the situation at the site, the storage facility must provide qualified personnel in sufficient numbers that ensures compliance with safety requirements and which is regularly trained.

In-service inspections are performed on the safety-relevant installations of the facilities, such as

- conditioning installations,
- lifting devices,
- alarm systems,
- equipment and systems for radiation protection,
- ventilation systems, where applicable.

The frequency of such testing is determined according to the safety significance of the components to be checked. Typical testing intervals are one or two years. The in-service inspections are specified in a testing manual. The results of the in-service inspections are documented and assessed.

The technical equipment used for the handling of the waste packages and the transportation thereof must remain available until all waste packages have been removed. In this respect, it is assumed that removal of the waste packages, e.g. for the purposes of emplacement in a repository, may take place over a longer period of time. To this end,

- the necessary systems and equipment of the facility (e.g. lifting devices) are kept either in a state of operational readiness or in such a state that operational readiness can be restored in the short term (e.g. by a recurrent test),
- auxiliary equipment (e.g. overpacks, special lading devices) required for transport is kept available,
- necessary type approvals for the cask types are permanently maintained,
- the waste packages are maintained in a condition that generally facilitates approval under traffic law provisions, and

- any aids required for obtaining approval under transport law provisions are provided (e.g. measuring and test devices, documentation).

H.6.5 Characterisation and segregation of radioactive waste

The process-based treatment of radioactive waste is divided in great detail into corresponding waste treatment categories: the radioactive waste is either raw waste that has not yet been treated, or it comes in the form of an intermediate or final product.

The sorting and segregation of the radioactive waste (if possible, already of the raw waste) and the preparation of the associated documentation are performed initially by the waste producer or by the delivering party. If required, the radioactive waste management facilities or storage facilities are equipped with the necessary means for the sorting of waste, having regard to all requirements relating to the radiological protection of personnel and the environment.

In view of the intended pretreatment and conditioning, Appendix X of the StrlSchV [1A-8] demands the sorting and segregation of the waste. Here, a distinction is made between seven main groups:

- solid inorganic waste,
- solid organic waste,
- liquid inorganic waste,
- liquid organic waste,
- gaseous waste,
- mixed waste (solid, liquid, inorganic, organic), and
- radioactive sources (sealed sources).

These are subdivided into further subgroups.

A further detailing of the categorisation is the distinction between untreated waste (raw waste), pretreated waste, waste products in inner containers, waste products in standardised waste containers according to the waste acceptance requirements for disposal in the Konrad repository, product-controlled waste products in inner containers, and product-controlled waste products in standardised waste containers in accordance with the waste acceptance requirements for disposal in the Konrad repository (waste packages suitable for disposal).

The waste characterisation system is sufficiently flexible to ensure that for each relevant waste type a clear allocation according to the processing condition, characterisation and treatment is always guaranteed.

H.6.6 Reporting of significant incidents

At present, the obligation of the operator to report safety-relevant incidents to the regulatory body is based on the appropriate application of the Nuclear Safety Officer and Reporting Ordinance (AtSMV) [1A-17] or on the stipulations in connection with licensing of the facility. The reporting duties and the reporting procedure are largely identical with the situation described in the remarks on Article 9(v).

H.6.7 Collection and analysis of operating experience

In view of the obligation of the authorities to take precautionary action, reports of incidents significant to safety are registered and evaluated at the incident registration centre of the Federal Office for the Safety of Nuclear Waste Management (BfE) (see reporting on Article 9(vi) in Chapter G.6.5).

Experiences from the operation of similar plants are taken into account by the plant management. This ensures that experiences, especially regarding

- the behaviour of package material,
- observations on gradual changes of the waste products,
- ageing phenomena of facility equipment as well as
- improvements to or deficiencies in the conditioning processes

are examined and evaluated with regard to their transferability. Here, international reporting systems (of the International Atomic Energy Agency (IAEA) and the OECD/NEA) are also considered. In this way, plant operation also makes adequate allowance for processes that occur very slowly as well as occurrences taking place rarely or only in case of certain waste. Procedures are provided which ensure the exchange of experiences (e.g. on the basis of operating reports) between the operators on the one hand, and the competent licensing and supervisory authorities and the experts consulted by them on the other, at adequate intervals.

A monitoring concept is drawn up to allow the detection and control of long-term and ageing effects during the operating life time of the storage facility. On the one hand, the monitoring concept includes an evaluation of results from previous inspections, including the experience from other facilities. On the other hand, it can also include special analyses that cannot be performed recurrently at regular intervals due to the effort involved and the slow speed of any anticipated detrimental changes.

The monitoring concept stipulates monitoring of the overall condition of the installation and the waste packages stored, and as a minimum requirement, must meet the following:

- At ten-year intervals, the operator prepares regular reports on the condition of the storage building, the components required for storage and handling, and the waste packages. In particular, these reports should also incorporate the findings of in-service inspections. The reports include a prognosis on the continued storability of the packages and waste types, as well as on the further development of the relevant retention properties of the building.
- The condition of the storage building and the components necessary for storage are also subjected to a special inspection at intervals of ten years. As a minimum requirement, these should include walk-downs and appropriate measurements. In addition, recurrent subsidence measurements are performed on the storage building and evaluated with regard to long-term detrimental changes.

All operational measures, controls, inspections and modifications are subject to the supervision of the competent authorities.

H.6.8 Preparation of decommissioning plans

For radioactive waste treatment and storage installations, the remarks made on Article 9(vii) apply, too.

H.6.9 Closure of repositories

For the decommissioning of a repository (closure in the sense of the Joint Convention), a plan approval decision or a licence in accordance with the Atomic Energy Act (AtG) must have been issued. So far, no repository in deep geological formations has been closed in the Federal Republic of Germany.

Repository for heat-generating radioactive waste

The “Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste” [BMU 10] stipulate that the decommissioning concept should be reviewed in line with the state of the art as part of the ten-yearly safety reviews and updated where necessary. At the same time, the mining law is also to be applied. According to § 55(1) of the Federal Mining Act (BBergG) [1B-15], operational plans for the construction and management of a facility may only be approved if the required precautions to facilitate reutilisation of the surface have been taken into account to the extent required under the prevailing circumstances. Furthermore, the relevant § 7(2) of the General Mining Ordinance on Underground Mines, Open-Cast Mines and Salt Mines (ABVO) [1B-15] stipulates that open shafts that are not maintained in a state which is safe and descendible are to be backfilled. An application for such backfilling must be submitted in a timely manner in the form of an operational plan.

This aspect of mining legislation therefore ensures that at the time of filing the final operational plan – which may be many years in the future from the date of approval of operation – any new knowledge acquired in the interim period can be duly taken into account.

Konrad repository

Plans relating to the closure of the mine workings and shafts of the Konrad repository for radioactive waste with negligible heat generation were filed and approved within the scope of the plan approval procedure that was concluded in May 2002. Concrete details of the measures required in order to comply with the protection targets following the cessation of emplacement operations have not yet been finalised. Due to the intended operating time for the Konrad repository of approx. 40 years, such details must be specified according to the state of the art in science and technology existing at that time within the context of separate procedures encompassing the requirements of nuclear legislation, mining and water legislation as well as other legal requirements.

Morsleben repository for radioactive waste

The decommissioning of the Morsleben repository for radioactive waste (ERAM) is in preparation. During this phase, all relevant information gathered during the operational period (until today) is taken into consideration. For example, the decommissioning plan incorporates findings from the geological, geotechnical, geochemical and mining fields. With respect to radiation protection, the potential release of radionuclides after decommissioning shall be limited to an acceptable level. It is required that the entire repository shall be sufficiently safely sealed against the biosphere (see reporting on Article 14(iii)). This has to be demonstrated by a site-specific long-term safety analysis. For such an analysis, partial systems and scenarios within the whole system are modelled using suitable models based on the most realistic assumptions. Apart from the requirements posed by radiation protection, requirements from other legal areas have to be taken into account.

According to § 9b AtG [1A-3], any major modifications of the Morsleben repository, i.e. also any measures concerning its decommissioning, require a plan approval decision by the competent environmental ministry of the *Land of* Saxony-Anhalt. In the scope of the licensing procedure for the ERAM, the only difference to the plan approval procedure according to § 9b AtG (see reporting on Article 19) consists in the fact that for this existing repository the operational phase is finished and that the corresponding procedures can only be directed at the requirements for safe decommissioning. The plan approval according to the Atomic Law states that the ERAM decommissioning plan is permissible with respect to all public interests which are touched. The licensing of the operating plans according to mining law lies within the responsibility of the mining authority of Saxony-Anhalt.

The plan approval procedure for operation of the repository which had been initiated in 1992 was restricted to decommissioning upon application of the BfS in 1997. The first step in the environmental impact assessment required as part of the plan approval procedure was to define the required documents according to § 5 of the Environmental Impact Assessment Act (UVPG) [1B-14]. Meanwhile, documents for the plan approval procedure relating to the decommissioning of ERAM have been submitted to the competent licensing authority, and the application documents were displayed for public inspection. The competent plan approval authority conducted the public hearing between 13 October and 25 October 2011. As a result of the public hearing, the BMUB asked the Nuclear Waste Management Commission (ESK) to examine whether the methodology used for the long-term safety assessment prepared by the BfS corresponded to the state of the art in science and technology. On 31 January 2013, the ESK presented its statement on the "Long-term safety case for the Morsleben repository for radioactive waste (ERAM)" [4-11a]. On 8 March 2013, the BfS was ordered by the BMUB to implement all the recommendations made by the ESK as the ESK statement established the state of the art in science and technology and hence there was certainty for further planning. Due to the implementation of the ESK recommendations and the not yet completed verification of the functioning of the shaft seals in rock salt and in anhydrite, the implementation of decommissioning will still require some time.

In parallel to the plan approval procedure for decommissioning, other measures for mining hazard control have been carried out on the basis of licences according to mining law. The long-term stability of the mine for the decommissioning measures has been ensured by backfilling cavities in the central part of the Bartensleben mine. In the course of these measures, 27 mine workings had been backfilled with 935,000 m^3 of rock salt concrete by the end of February 2011. This did not anticipate any measures for decommissioning; in particular, backfilling of disposal areas was not part of these measures.

The ERAM was designed and taken into operation at the time of the former German Democratic Republic (GDR). After takeover as a federal repository in the course of the German reunification, new conclusions from the operational phase and from dedicated geological, geotechnical, geochemical and mining technique assessments were used for the development of a decommissioning concept. It provides that any yet open underground workings be largely filled with rock salt concrete. This is to ensure as far as possible the integrity of the protective salt layers around the underground workings and keep the mine dry. In addition, in case of a brine inflow into the mine, which cannot be fully excluded, the emplacement areas East Field, South Field and West Field, i.e. the major mine workings used for the disposal of radioactive waste and their wider surroundings, will be hydraulically isolated from the rest of the mine workings by sealing of the drifts. The in 2010 erected in-situ sealing structure in rock salt has meanwhile (as of 30 June 2016) reached the target of an integral permeability of $\leq 10^{-18}$ m^2 despite the questions on building technology still left. The decommissioning concept further includes the sealing of both shafts of the ERAM by systems of sealing elements of various materials with low permeability in order to minimise the inflow of groundwater from the overlying rock via the shafts into the mine and the discharge of radionuclides in solution from the mine via the shafts into the overlying rock.

H.7 Article 17: Institutional measures after closure

> ***Article 17: Institutional measures after closure***
>
> *Each Contracting Party shall take the appropriate steps to ensure that after closure of a disposal facility*
>
> *i) records of the location, design and inventory of that facility required by the regulatory body are preserved;*
>
> *ii) active or passive institution al controls such as monitoring or access restrictions are carried out, if required;*
>
> *iii) if, during any period of active institution al control, an unplanned release of radioactive materials into the environment is detected, intervention measures are implemented, if necessary.*

H.7.1 Documentation

Repository for heat-generating radioactive waste

The "Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste" [BMU 10] include the requirement as regards the documentation after sealing of the repository that, prior to decommissioning, binding regulations concerning the scope, the preservation and accessibility of the documentation to be retained shall be adopted. The documentation must contain all operating data and documents which could contain relevant information for future generations. In particular, this should include information being relevant for the protection of the repository mine against human intervention in the deep subsoil. For safeguarding all the information, complete sets of documents must be stored in at least two different suitable locations.

The final report of the Commission on Storage of High-Level Radioactive Waste [BMU 10] includes specific requirements as regards the documentation requirements concerning the post-operational phase of a repository; from today's view, these specific requirements on data and documents are necessary for the period following the closure of the repository.

These are as follows:

- "results (evaluation and documentation) of all accompanying measurements in the surrounding of the repository; and also the results of data that can be obtained within the sealed repository by the possible measurement methods
- continuation of comparative analyses of past and present measurements
- update of the long-term safety analyses, including documented delta analyses of past and present analyses"

As regards a future repository for heat-generating radioactive waste, the recovery of the disposal containers from the sealed repository shall be possible over a period of 500 years after closure, thus, in case of a decision for recovery, information of the former repository operation shall be available. In accordance with the Commission's recommendations, these are:

- "local geological data by means of which bases for the precise geometrical localisation of the recovery mine to be newly erected can be derived from,
- the data for the precise localisation of all casks deposited,

- the data of containers and inventory of the cask to be recovered.”

In principle, all data and documents are to be stored permanently, i.e. without a prescribed period. For this purpose, separate organisational units are to be established from the very start within the competent organisations (project implementer and regulatory authority) concerned with the archiving of documents at locations for redundant storage, but also with the regular review of the quality and availability of the documents in the sense of data retention and data dissemination. Dissemination of data must be organised in such a way that apart from the readability and accessibility also the awareness of importance of these data and documents is maintained. These tasks are cross-generational and are to be continued after the closure of the repository without interruption. The Repository Site Selection Act (StandAG) [1A-7a] grants the power to issue statutory ordinances for the determination of details concerning data to be permanently stored by the Federal Office for the Safety of Nuclear Waste Management (BfE), which, taking into account the above mentioned recommendations, has to be executed by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB).

Konrad and ERAM repositories

The official plan approval for the Konrad repository includes the regulations governing the post-operational period. A collateral clause stipulates the following:

> “Documentation must be provided during construction, operation and decommissioning of the repository, comprised of data relating to the mine survey of the repository, the characteristics of the wastes deposited (type, quantity, emplacement area, nuclide spectrum, activities), as well as the relevant technical measures. Full sets of documentation must be kept by the operator of the repository at a suitable place and must be duly protected. In addition, the operator must provide full sets of documentation for the atomic authority and for the competent mining office, respectively, which are to be kept under protection in separate locations. The sets of documentation kept by the supervisory authorities must be updated on an annual basis as long as the repository is operational or in the process of decommissioning. For the period following its closure, the form, extent and the storage locations (at least at two separate locations) of the long-term documentation must be specified in the closure plan and submitted to the supervisory authorities for approval.”

It can be assumed that the regulations laid down in the plan approval notice for the post-operational phase of the Konrad repository will act as a precedent for the Morsleben repository for radioactive waste (ERAM). This repository is being closed, and the required measures for backfilling and closure are currently being planned.

H.7.2 Monitoring and institutional control

Repository for heat-generating radioactive waste

The currently valid “Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste” [BMU 10] require that following decommissioning of the repository, evidence preservation and control measures must be carried out. Prior to the completion of sealing work, it is necessary to determine which measures are to be carried out, which organisation shall perform them, and which resources will be made available for this purpose. For the period after closure, administrative precautions shall be implemented to ensure, as effectively as practically possible, that no human activities which could endanger the permanent containment of the radioactive waste are carried out in the vicinity of the repository.

The final report of the Commission on Storage of High-Level Radioactive Waste [KOM 16] includes fundamental requirements for repository monitoring starting with the site investigation, continued during the entire disposal process, and further developed according to the information needs and instrumental possibilities.

In respect of the long-term character of repository monitoring, the Commission states the following:

> "An active repository monitoring is required […] at least until the recoverability of the casks ends as provided by design. It is not possible to specify methods for this long-term monitoring, however, the requirement that repository monitoring has to comply with the state-of-the-art in science and technology during all stages has to be established yet, and that in this respect, a dedicated further development of the methods of monitoring the safety of the repository has to be fostered. Since there can be no end point for repository monitoring, it is to be expected that a society informed about the existence of a repository will want to monitor the repository site or the objects to be protected surrounding it (e.g. surface, ground water) in the long-term. Time will tell which methods will be used, but a precautionary documentation might provide a basis for decision-making for future generations."

Konrad and ERAM repositories

Institutional control after closure is regulated in the licence for the Konrad repository as follows:

> "No special control and surveillance programme is envisaged for the period following closure. However, routine measurements of the environmental media air, water and soil must be conducted on the area surrounding the repository in accordance with the relevant regulations. These measurements must be examined for any evidence of impacts from the repository and documented in a suitable format. The extent and type must be specified in the closure plan and the results added to the long-term documentation."

The procedures for the ERAM have not yet been specified.

H.7.3 Unplanned release

The usual inspection of surface settlement for all present and future underground repositories in Germany is carried out within the regime of mining law. The routine measurements of air, water and soil samples are likewise carried out in the area surrounding a repository, in accordance with legal requirements. In this way, any unplanned releases of radioactive substances may be detected and any measures which may be required by the competent authorities in order to avoid or mitigate any hazards can then be initiated.

In its final report [KOM 16], the Commission on Storage of High-Level Radioactive Waste has stated that, with regard to a future repository for heat-generating radioactive waste, repository monitoring is a technical/scientific decision-making basis for failure detection. Here, standards have to be developed enabling the categorisation of deviations from expected values of the measured parameters as failures *"requiring corrective measures"*. This includes the direct or indirect detection of unplanned releases of radioactive substances.

For the Konrad repository, no special control and surveillance programme is envisaged for the period following closure. The extent and the type of the routine measurements of the environmental media air, water and soil on the area surrounding the repository must be specified in the closure plan and the results added to the long-term documentation.

According to current planning, the Asse II mine will be closed once the radioactive waste has been retrieved. After successful retrieval, unplanned releases of radioactive substances are not to be expected and thus, no specific measures, as referred to in Article 17(iii) are to be provided.

Exhaust air and surroundings of the ERAM and the Asse II mine are currently continuously monitored by the operator as well as by an independent measuring institution. The necessary programmes are based on the Guideline concerning Emission and Immission Monitoring of Nuclear Installations (REI) [3-23].

I Transboundary movement

This section deals with the obligations under Article 27 of the Convention.

Developments since the Fifth Review Meeting:

The newly introduced § 3(6) of the Atomic Energy Act (AtG) allows granting of a licence for the export of spent fuel from installations for the fission of nuclear fuel for research purposes only for serious reasons of non-proliferation of nuclear fuel or for reasons of a sufficient supply of fuel elements for medical and other top level research purposes.

I.1 Article 27: Transboundary movement

Article 27: Transboundary movement

(1) Each Contracting Party involved in transboundary movement shall take the appropriate steps to ensure that such movement is undertaken in a manner consistent with the provisions of this Convention and relevant binding international instruments.

In doing so

i) a Contracting Party which is a State of origin shall take the appropriate steps to ensure that transboundary movement is authorised and takes place only with the prior notification and consent of the State of destination;

ii) transboundary movement through States of transit shall be subject to those international obligations which are relevant to the particular modes of transport utilised;

iii) a Contracting Party which is a State of destination shall consent to a transboundary movement only if it has the administrative and technical capacity, as well as the regulatory structure, needed to manage the spent fuel or the radioactive waste in a manner consistent with this Convention;

iv) a Contracting Party which is a State of origin shall authorise a transboundary movement only if it can satisfy itself in accordance with the consent of the State of destination that the requirements of subparagraph (iii) are met prior to transboundary movement;

v) a Contracting Party which is a State of origin shall take the appropriate steps to permit re-entry into its territory, if a transboundary movement is not or cannot be completed in conformity with this Article, unless an alternative safe arrangement can be made.

(2) A Contracting Party shall not licence the shipment of its spent fuel or radioactive waste to a destination south of latitude 60 degrees south for storage or disposal.

(3) Nothing in this Convention prejudices or affects:

i) the exercise, by ships and aircraft of all States, of maritime, river and air navigation rights and freedoms, as provided for in international law;

ii) rights of a Contracting Party to which radioactive waste is exported for processing to return, or provide for the return of the radioactive waste and other products after treatment to the State of origin;

> *iii) the right of a Contracting Party to export its spent fuel for reprocessing;*
>
> *iv) rights of a Contracting Party to which spent fuel is exported for reprocessing to return, or provide for the return of, radioactive waste and other products resulting from reprocessing operations to the State of origin.*

I.1.1 Obligation of licensing transboundary movements

Transboundary movements of spent fuel and radioactive waste are, according to Council Directive 2006/117/EURATOM [1F-35], subject to licensing in Germany (and in other Member States of the European Union (EU)). Current German legislation requires that the carrier must submit an application to the licensing authority Federal Office for Economic Affairs and Export Control (BAFA) for each shipment of these materials from Germany. The BAFA must determine whether all legal provisions for the licence for transboundary movement have been met and if so, grants the licence. In principle, a licence for a given quantity of material may be used for several individual shipments of partial amounts. In the case of shipment of spent fuel and radioactive waste from other EU states to Germany, the licensing authority in the delivering country shall be responsible; however, the BAFA is also consulted. With its approval, which is subject to certain conditions, the BAFA can lay down provisions or, if necessary, can refuse the approval on reasoned grounds.

Transboundary movements of spent fuel and radioactive waste will only be authorised if compliance with the safety measures outlined in the comments on Articles 4 to 17 and 21 to 26 is ensured, and compliance with the provisions of international conventions has been checked. This applies equally for the granting of approval in case of consultation.

Authorisation of transboundary movements and coordination with the state of destination

Spent fuel

Essential for all transboundary movements of spent fuel to, through or from the Federal Republic of Germany is the “Ordinance on the Shipment of Radioactive Waste or Spent Fuel (Nuclear Waste Shipment Ordinance)” – AtAV [1A-18])“ by which the Council Directive 2006/117/EURATOM [1F-35] was transposed into national law; according to § 6 and 7 of the AtAV, the BAFA is the competent authority for this. A licence will only be granted if there are no concerns regarding the applicant’s reliability and if compliance with national and international safety regulations is ensured.

It primarily comprises the following provisions:

Transboundary movements within the European Community

The sender of spent fuel applies to the competent authority in his country (in Germany, this is the BAFA) for a licence. There is a standard form available for this purpose, which is divided into different sections. Section B-1 is the application form. The competent authority forwards a copy of this section together with Section B-2 (“Acknowledgement of receipt of application for spent fuel shipment(s) – Request for missing information”) and Section B-3 (“Refusal or consent of spent fuel shipment(s) by the competent authorities concerned”) to the competent authority in the member state of destination (which in the case of shipments to Germany is the BAFA). Section B-3 is only approved by the BAFA and mailed back to the competent licensing authority provided both the consignee and his competent supervising authority have likewise given their consent to the proposed shipment. Section B-4a (“Authorisation of spent fuel shipment(s)”) can then be issued and handed over to the applicant.

During a shipment, all documents must be carried, including Section B-5 (“Description of spent fuel consignment and list of packages) and Section B-6 (“Acknowledgement of receipt of the spent fuel”).

In advance of each shipment all the aforementioned documents must be transmitted to all authorities concerned. In order to ensure that all authorities concerned are informed about every shipment, and to enable them to log the quantities delivered, they regularly receive copies of the respective Sections B-5 and B-6.

Transboundary movements to or from states which are not members of the European Community (third countries)

In case of shipments from Germany to a third country, the BAFA will only grant a licence to the holder or sender of the spent fuel if the competent authority of that third country has confirmed to the BAFA that the consignee holds the necessary licence and the necessary equipment to handle such spent fuel, and it has been proven that the respective specified criteria for the export of spent fuel to third countries have been met.

In case of shipments from a third country to Germany, the consignee is the applicant, and will only receive a licence from the BAFA provided he holds the necessary licence and the necessary equipment to handle such spent fuel or has notified such handling in accordance with an existing obligation.

In case of shipments from Germany, it is additionally necessary to ensure that the state of destination will not put the consignment to any use whatsoever in a manner that will compromise international obligations of the Federal Republic of Germany in the nuclear field or its internal or external security.

Observance of these additional provisions is checked by the BAFA on the basis of contracts and declarations which must be submitted by the state of destination.

In the case of return deliveries e.g. of spent fuel from research reactors back to the United States of America, export can only take place after the issue of an official import certificate there. For other states, an exchange of notes takes place between the affected governments prior to the delivery, as part of the licensing procedure under foreign trade law.

<u>Radioactive waste</u>

Each transboundary movement of radioactive waste is subject to the provisions of Council Directive 2006/117/EURATOM [1F-35]. This Directive was transposed into national law by the AtAV [1A-18] as already mentioned above. It primarily comprises the following provisions:

Transboundary movements within the European Community

The holder respectively the sender of radioactive waste applies to the competent authority in his country (in Germany, this is the Federal Office for Economic Affairs and Export Control (BAFA)) for a licence for shipment. There is a standard form available for this purpose, which is divided into different sections. Section A-1 is the application form. The competent authority forwards a copy of this section together with Section A-2 (“Acknowledgement of receipt of application for radioactive waste shipment – Request for missing information”) and Section A-3 (“Refusal or consent of the radioactive waste shipment by the competent authorities concerned”) to the competent authority in the state of destination (which in the case of shipments to Germany is the BAFA). This Section A-3 is only approved by the BAFA and mailed back to the competent licensing authority provided both the consignee and his competent supervising authority have likewise given their consent to the proposed shipment. Section A-4a (“Authorisation of radioactive waste shipment”) can then be issued and handed over to the applicant.

During a shipment, all documents must be carried, including Section A-5 (“Description of radioactive waste consignment and list of packages) and Section A-6 (“Acknowledgement of receipt of the radioactive waste”).

In advance of each shipment all the aforementioned documents must be transmitted to all authorities concerned. In order to ensure that all authorities concerned are informed about every shipment, and to enable them to log the quantities delivered, they regularly receive copies of the respective Sections A-5 and A-6.

Transboundary movements to or from states which are not members of the European Community (third countries)

In case of shipments from Germany to a third country, the BAFA will only grant a licence to the holder or sender of the radioactive waste if the competent authority of that third country has confirmed to the BAFA that the consignee holds the necessary licence and the necessary equipment to handle such radioactive waste, and it has been proven that the respective specified criteria for the export of radioactive waste to third countries have been met.

In case of a shipment from a third country to Germany, the consignee is the applicant, and will only receive a licence from the BAFA provided he holds the necessary licence and the necessary equipment to handle such radioactive waste or has notified such handling in accordance with an existing obligation.

Transboundary movement through states of transit

In the case of transit through Germany of spent fuel or radioactive waste the provisions of the AtAV [1A-18] also apply. Supervision of the transit of spent fuel with regard to the compliance with national and international regulations is also performed by the Federal Office for the Safety of Nuclear Waste Management (BfE), and in case of transportation by rail, the Federal Office for Railways (EBA).

In the case of transit of radioactive waste or spent fuel, the BAFA must be consulted under the provisions of Council Directive 2006/117/EURATOM [1F-35] or of the AtAV; these transits therefore are subject to approval. Such approval will only be granted if there are no facts leading to concerns vis-à-vis proper delivery to the country of destination.

Compliance with safety provisions by the consignee in Germany

Transboundary movements of spent fuel and radioactive waste will only be licensed by the expert staff at Germany's competent authority, the BAFA, provided the consignee in Germany ensures that such materials conform to the safety measures outlined in the comments on Articles 4 to 17 and 21 to 26. Prior to receiving such material, the consignee must apply to the BAFA for a licence under the statutory provisions outlined with respect to Article 27(1)(i). The BAFA will verify compliance with these provisions.

Compliance with the safety provisions by the consignee in the state of destination

In the case of deliveries of spent fuel from Germany, a licence will only be granted provided the consignee, according to the documents available, fulfils the provisions outlined under Article 27(1)(iii), i.e. the international and/or European provisions are met and there are no substantiated doubts that this is so. In the case of deliveries of radioactive waste and spent fuel out of Germany, the requirements outlined in Article 27(1)(iii) are furthermore met by the consultation process pursuant to the AtAV in conjunction with Council Directive 2006/117/EURATOM [1F-35] (see reporting on Article 27(1)(i) and (ii)).

Possibility of re-import

In accordance with Directive 2006/117/EURATOM [1F-35] respectively the AtAV [1A-18], the re-import of spent fuel or radioactive waste into Germany is possible in principle; the provisions in this respect were explained under Article 27(1)(i).

Principally, a shipment of radioactive waste or spent fuel under the AtAV in conjunction with Council Directive 2006/117/EURATOM allows the option of return shipment in case the envisaged delivery cannot be completed.

According to § 8(1)(3) AtAV, shipment to another EU Member State will only be licensed provided measures are taken to ensure that the radioactive waste or the spent fuel will be taken back by the original owner/sender if delivery cannot be completed or the provisions for its shipment cannot be met.

According to § 9(1)(4) AtAV, shipment to a third country will likewise only be licensed provided measures are taken to ensure that the radioactive waste or spent fuel will be taken back by the original owner/sender if delivery cannot be completed or the provisions for its shipment cannot be met.

According to § 10(1)(3) AtAV, shipment from a third country into Germany will only be licensed provided the domestic consignee of the radioactive waste or spent fuel has reached a binding agreement with the foreign owner/sender of the radioactive waste or spent fuel, with the consent of the competent authority in the third country, that the foreign owner/sender will take back the radioactive waste if the shipment process cannot be completed.

Finally, according to § 14(1)(2) AtAV, the Federal Office for Economic Affairs and Export Control (BAFA) may only give its approval to a shipment from another EU Member State to Germany provided measures have been taken to ensure that the radioactive waste or spent fuel will be taken back by the original owner/sender if delivery cannot be completed or the provisions for its shipment cannot be met.

I.1.2 Antarctic Treaty

Germany ratified the Antarctic Treaty of 1 December 1959 [ANT 78] on 22 December 1978. Article V of this Treaty includes a ban on the shipment of radioactive waste south of latitude 60 degrees South. The Treaty was incorporated into national law and entered into force on 5 February 1979, thereby obligating Germany to comply with this ban. § 5 AtAV [1A-18] likewise prohibits shipments into this region.

I.1.3 Sovereignty demarcations

Maritime traffic and river navigation

With respect to the freedom of international maritime traffic, Germany has legally committed itself to observe the requirements of this Article insofar as it has acceded to the United Nations Convention on the Law of the Sea of 10 December 1982. It was transformed into national law by the Act on the United Nations Convention on the Law of the Sea of 10 December 1982 [UN-CLOS 94].

With regard to the freedom of river navigation, it should be noted that Germany is a contracting party to the Revised Convention for Rhine Navigation of 17 October 1868 [RHE 69] and to the Convention of 27 October 1956 on the Canalisation of the Moselle [MOS 57].

Air traffic

With respect to air traffic, the requirements of this Article are met by Germany's accession to the International Air Services Transit Agreement [LIN 56]. This Agreement stipulates that the Member States shall reciprocally grant one other the rights of the so-called first and second freedoms of air traffic, i.e. the right to pass over and to land for technical reasons. These commitments have been transformed into national law by the Act of Approval on the basis of Article 59(2) of Germany's Basic Law (GG) [GG 49].

Return of radioactive waste after treatment

The rights referred to in this Article are not impaired by the incorporation of the Joint Convention into German legislation. German legislation does not include an obligation to accept the return of waste; it is instead agreed contractually with these export procedures. Apart from that, Article 2 of Council Directive 2006/117/EURATOM [1F-35] applies.

Shipment of spent fuel for reprocessing

Since 30 June 2005 it is no longer admissible to ship any German spent nuclear fuel from facilities for fission of nuclear fuels for the commercial generation of electricity to a facility for reprocessing of irradiated nuclear fuels, not because of the incorporation of the Joint Convention in the German legislation, but by virtue of the amendment to the German Atomic Energy Act (AtG) of 22 April 2002.

The Act Amending the Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste and for the Amendment of Other Laws, which largely entered into force on 16 May 2017, includes amendments to the AtG related to the export of nuclear fuel. In accordance with the newly introduced § 3(6) AtG, the following applies:

After the amendment to the AtG according to the Act Amending the Repository Site Selection Act (StandAG) [1A-7b], export of spent fuel from research reactors is only permitted for serious reasons of non-proliferation of nuclear fuel or for reasons of a sufficient supply of fuel elements for medical and other top level research purposes. An exception to this is the shipment of such fuel assemblies with the aim of producing waste packages that are suitable for disposal and that are to be disposed of in Germany. An export licence shall not be granted if the spent fuel is already stored in Germany pursuant to § 6 AtG.

Return of material from reprocessing

The right referred to in this Article is not impaired by including the Joint Convention in the German legislation. On the contrary: in an exchange of notes with the French government and with the British government of 1979 and 1990/1991, respectively, the German government reinforced the rights of both these nations to return the waste and other products generated from the reprocessing of German spent fuel to Germany.

J Disused sealed sources

This section deals with the requirements under Article 28 of the Convention.

> **Developments since the Fifth Review Meeting:**
>
> The amount of data relating to sealed sources in the high-activity sealed sources (HASS) register, maintained by the Federal Office for Radiation Protection (BfS), has increased significantly. The HASS register is continuously further developed with regard to accessibility and usability while maintaining a high level of safety and security.

J.1 Article 28: Disused sealed sources

> ***Article 28: Disused sealed sources***
>
> *(1) Each Contracting Party shall, in the framework of its national law, take the appropriate steps to ensure that the possession, remanufacturing or disposal of disused sealed sources takes place in a safe manner.*
>
> *(2) A Contracting Party shall allow for re-entry into its territory of disused sealed sources if, in the framework of its national law, it has accepted that they be returned to a manufacturer qualified to receive and possess the disused sealed sources.*

J.1.1 Measures for the safe handling of disused sealed sources

Nearly 100,000 sealed radioactive sources are used in research, trade, industry, medicine and agriculture in Germany, of which approx. 15,000 radioactive sources are to be classified as high-activity sealed sources (HASS). The most common fields of application for sealed radioactive sources in the industry are calibration of measuring devices, materials testing, irradiation and sterilisation of products, as well as level and density measurement. In medicine, sealed radioactive sources are mostly used for radiotherapy and for irradiation of blood. The most frequently used radionuclides in radioactive sources are Co-60, Ir-192, Cs-137, Sr-90 and Am-241 whose activity is in the range of some kBq for test and calibration sources and up to some TBq for sealed radioactive sources for irradiation facilities. In Germany, the safety and security of disused sealed radioactive sources has long been ensured by a legal framework in accordance with European and international standards and by an extensive system of licensing and supervision.

Improvement of the control of disused sealed radioactive sources is therefore a decisive measure in the efforts to avoid any exceptional exposure of humans, the environment and material goods. In this respect, Germany has transposed all relevant European Union (EU) directives. The guideline 2013/59/EURATOM [1F-24] is currently being implemented. In the following, the experiences made with the HASS register at the Federal Office for Radiation Protection (BfS) and the international context of control of sealed radioactive sources are described.

High-activity sealed sources (HASS) and the HASS register at the BfS

Based on Council Directive 2003/122/EURATOM of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sealed radioactive sources [1F-22], the Act on the

Control of High-Activity Sealed Radioactive Sources [1A-23] entered into force in August 2005. The scope of application of the act is limited to high-activity sealed radioactive sources. The necessary amendments to the Atomic Energy Act (AtG) [1A-3] and the relevant regulations have been made.

§ 70a of the Radiation Protection Ordinance (StrlSchV) contains requirements for the register of high-activity sealed radioactive sources that is kept at the Federal Office for Radiation Protection (BfS). According to § 12d(2) AtG, the data on HASS have to be transmitted to the register by the licence holder. The National Report for the Fourth Review Meeting described the establishment and operation of the HASS register.

The responsibilities of those authorised to access the HASS register can be summarised as described in the following.

- Licence holder: Notification regarding the acquisition, the transfer and the use of a HASS (including its loss or discovery) to the BfS. The licence holder submits the data using the standard record sheet of Appendix XV StrlSchV [1A-8] in secured electronic form. For safety and security reasons, the licence holder has no direct access to the database.

- The competent authority of the individual *Land*: Verification of the data submitted by the licence holder, the loss or discovery of HASS, reports and analyses. The authority has access to the database.

- The BfS: Operation and maintenance of the database, preparation of reports and analyses, check of the data for plausibility, data entry, providing users with advice, development of software and hardware. The BfS is the legally designated operator of the database.

- Federal Office of Economics and Export Control (BAFA): Data entry from permits issued for the shipment of high-activity sealed radioactive sources from non-EU countries (entry).

- Other authorities: Reports and analyses if access by security authorities (offices of criminal investigation, police, etc.) is required. These authorities have a read-only access.

Safe and secure operation of the HASS database is ensured by a number of administrative and data related measures.

The HASS register has been operated since July 2006 and meets the requirements of the above mentioned European directive. The system is accepted by licence holders and authorities and is subject to continuous further development with regard to accessibility, also for the licence holders, and user-friendliness while maintaining a high level of safety and security. The development of the data in the HASS register since 2006 is shown in Table J-1. For a total of 42,000 radioactive sources, 170,000 communications were stored in the database by the end of 2016. However, only about 45 % of these are above the HASS threshold activity level and 30 % are falling under the scope of the German StrlSchV.

Table J-1: Development of the data in the HASS register since 2006 [BfS 14a]

Status	Licence holder	Authorities	Radioactive sources	Communications
End of 2006	321	43	1,740	3,139
End of 2007	453	47	7,625	16,863
End of 2008	540	47	13,800	32,600
End of 2009	580	49	17,300	49,200
End of 2010	590	49	20,100	63,000
End of 2011	630	50	23,500	79,000
End of 2012	646	60	27,200	97,200
End of 2013	657	64	31,000	115,300
End of 2014	667	73	35,000	134,000
End of 2015*	684	73	40,000	153,000
End of 2016*	694	73	42,000	170,000

* BfS annual report for 2015 not published yet at the time of reporting. Data in accordance with the HASS register.

General requirements for sealed radioactive sources

According to § 7 StrlSchV [1A-8], the use of sealed radioactive sources requires a licence. There is an exception for test sources whose activity does not exceed the exemption levels of Appendix III, Table 1, Column 2 or 3 StrlSchV (§ 8(1) in conjunction with Appendix I, Part B, No. 1 and 2 StrlSchV), and for type-approved devices that may contain sealed radioactive sources (§ 8(1) in conjunction with Appendix I, Part B, No. 4 StrlSchV).

Furthermore, § 69(1) StrlSchV stipulates that radioactive substances that may only be handled on the basis of a licence, among others according to § 7 StrlSchV, shall only be transferred to persons who are in possession of the requisite licence. According to § 69(2) StrlSchV, anyone delivering radioactive substances to third parties for further use shall certify to the procuring party that the casing is leak-proof and free of contamination. High-activity sealed radioactive sources may only be transferred if they are accompanied by a documentation of the manufacturer specified according to StrlSchV. § 69(3) and 4 StrlSchV regulate transport and transfer to the recipient. Non-compliance with these provisions of § 69 will be fined according to § 116 StrlSchV as an administrative offence. In addition, § 328(1)(2) Criminal Code (StGB) [1B-1] stipulates that the storage, shipment, handling, processing, other use as well as import and export without the requisite licence or contrary to an enforceable prohibition of such other radioactive substances which because of their nature, composition or quantity are capable of causing the death of or serious injury to another by ionising radiation is punishable.

According to § 70(1) StrlSchV, the competent authority must be notified within one month of any extraction, production, acquisition, transfer and whereabouts of radioactive material and therefore also of sealed radioactive sources, specifying type and activity, and records on it must be kept. For any handling of high-activity sealed radioactive sources there is an additional duty of informing the Federal Office for Radiation Protection (BfS) thereof. The scope of the information to be provided is clearly regulated (see below). § 70(4) StrlSchV requires that a certificate of tightness of sealed radioactive sources is to be attached to the notification on the acquisition of the radioactive source submitted to the authority. Type-approved devices into which radioactive substances are embedded and that may be used without a licence in accordance with § 8(1) in conjunction with Appendix I, Part B, No. 4 StrlSchV must be returned immediately to the authorisation holder (in Germany, this is usually the manufacturer or distributor) after end of use according to § 27(1)(5) StrlSchV.

The German regulatory framework transposes those parts of the Council Directive 96/29/EURATOM [1F-18] that are binding for radioactive sources as well as the Council Directive 2003/122/EURATOM [1F-22] and also takes into account the relevant recommendations and guidance documents of the International Atomic Energy Agency (IAEA) (see Chapter J.1.3 on international aspects).

Management of disused sealed radioactive sources

The working lives of the sealed radioactive sources used are very different, in particular due to the strongly varying half-lives of the radionuclides used. In most cases, the devices operated on the basis of a licence for handling are returned to the equipment manufacturer by the operator after end of use together with the sealed radioactive source remaining in the device. The manufacturer may check further use of the sealed radioactive sources or returns them to the source manufacturer who may reuse parts of them. The sealed radioactive sources that cannot be reused are delivered to the *Land* collecting facilities where they are stored until delivery to the Konrad repository.

The general national regulations for the disposal of radioactive waste are included in the AtG. § 9a AtG stipulates that the *Länder* shall establish collecting facilities for the storage of the radioactive waste originating within their territories. §§ 72 to 79 StrlSchV regulate the obligation to report to the supervisory authorities of the *Länder*, the type and extent of the notifications as well as the treatment, packaging, storage and delivery of the radioactive waste.

Disused sealed radioactive sources arising from handling licensed pursuant to § 7 StrlSchV are delivered to the *Land* collecting facilities. The inventory of the *Land* collecting facilities in Germany varies considerably. In the *Land* collecting facility Saxony, for example, approx. 800 individual sealed radioactive sources packed in different waste packages are stored. Every single sealed radioactive source is documented separately regarding the properties like type, origin, date of delivery, original and current activity, storage position etc. For the most part, these are Co-60, Cs-137, Am-241, Kr-85, Pu-239, Cf-252, Sr-90 sources and some other nuclides. The users are made up of very wide-ranging groups of schools and education institutions, industry, medicine and research and also sources from smoke detectors and other devices.

According to the waste acceptance requirements for the disposal of waste packages, there are no special requirements with regard to the processing, packaging and labelling of sealed sources. In the collecting facilities of the *Länder*, disused sealed radioactive sources are usually conditioned and documented together with other radioactive waste. For conditioning, the same procedures are applied as for radioactive waste. It is carried out according to procedures qualified by the BfS or the Bundes-Gesellschaft für Endlagerung mbH (BGE) with the objective of producing waste packages that are suitable for storage and disposal. The requirements to be met for the waste packages to be disposed of are laid down in the respective waste acceptance criteria. The compliance of the packages with the requirements set out in the acceptance criteria of the repository is reviewed within the scope of a product control. Subsequent to product control and confirmation that the waste packages produced in this way are suitable for emplacement, the *Länder* will deliver them to the Konrad repository (after its commissioning).

Safe disposal of disused sealed radioactive sources

Responsibility of manufacturers and suppliers

The manufacturers and suppliers of radioactive sources in Germany shall ensure that the sealed radioactive sources are only delivered to users who hold the appropriate use licence in the respective country of use. In addition, in case of transboundary shipment, the corresponding external regulations must be complied with. Furthermore, the manufacturers and suppliers take back the radioactive sources that are no longer used to the extent permitted by national regulations to ensure the safe management of sealed radioactive sources during the entire life cycle.

Continued use/extended use of radioactive sources

Sealed radioactive sources no longer to be used for their original purpose and meeting the necessary quality requirements can continue to be used for other purposes or by other users having a relevant handling licence. In such a case, in Germany, the sealed radioactive source is transferred in accordance with § 69 of the Radiation Protection Ordinance (StrlSchV), to other EU states in accordance with the Council Regulation No. 1493/93/EURATOM and from Germany to third countries within the licence and notification procedure according to §§ 19 and 20 StrlSchV (see Chapter I.1).

If continued use is not an option, there is the possibility to either deliver the sealed radioactive sources to its manufacturer or, in case these are declared as radioactive waste, to deliver the sealed radioactive sources as radioactive waste in accordance with the national rules and regulations. In Germany, radioactive waste originating during handling as defined in § 7(1) StrlSchV or from the operation of facilities for the generation of ionizing radiation subject to licensing must generally be delivered to the *Land* collecting facility according to StrlSchV, unless any other disposal or shipment has been approved by the competent authority (see Chapter E.2.7).

In Germany, the manufacturers and suppliers offer their customers to take back the sealed radioactive sources after use. It is a common practice to return the sealed radioactive sources with relatively short half-life where a regular source exchange is necessary e.g. for medical use or for non-destructive tests to the manufacturer or supplier. This option is becoming increasingly common also among users of longer half-life sealed radioactive sources. Besides the considerations of waste minimization, licensing, logistical and economic reasons also play an important role.

In Germany, the legal means of the manufacturers or suppliers for the acceptance of sealed radioactive sources no longer in use are, however, largely limited to the return of sealed radioactive sources from its own production or return for recycling.

Recycling of sealed radioactive sources by the manufacturer

There are no restrictions regarding the return of sealed radioactive sources to the manufacturer/supplier if these are recyclable.

In recent years, the manufacturers of radioactive sources increased their recycling capacity of sealed radioactive sources with the objective of waste reduction.

However, due to the decrease of activity concentration, there are technological limits with regard to recycling of radioactive materials from sealed radioactive sources. At the same time, recycling requires complex technological processes which may result in economical limitations.

The number of the sources which can be recycled depends on their type and activity. Approx. 30 % of sealed radioactive sources used for process control and for measurement technology is recyclable.

Today, the recycling activities concentrate on sealed radioactive sources where Co-60, Kr-85, Cs-137, Am-241 and Am-Be are the dominating radionuclides.

Sealed radioactive sources as radioactive waste

Sealed radioactive sources to be disposed of as waste are generally to be delivered to the *Land* collecting facilities (see Chapter E.2.7). Such a delivery is subject to special requirements of the individual *Land* collecting facility (e.g. activity limitations, type of waste, physical form, packaging, transportation). These requirements may have the effect that delivery of sealed radioactive sources to *Land* collecting facilities is either not or only possible with considerable effort. For the manufacturers and users of sealed radioactive sources, the disposal of sources no longer in use may present a great challenge.

Practical handling of disused sealed radioactive sources by the *Land* collecting facilities

According to § 9a AtG, the *Länder* shall be obliged to establish *Land* collecting facilities for radioactive waste (see Chapters B.1.3 and E.2.3). Thus, regulated waste management possibilities and relatively short transportation routes within their *Land* are available for companies and research institutions obliged to deliver. The following examples from Baden-Wuerttemberg and Saxony present the aspects of practical handling of disused sealed radioactive sources.

***Land* collecting facility of Baden-Wuerttemberg (LSSt BW)**

Waste delivered to the *Land* collecting facility LSSt BW originates from different commercial sectors, from research and development, from medical use and the public administration sector. Altogether, this waste is mostly combustible material which can be disposed of by incineration. But also solid waste which is non-combustible like e.g. metals and glass is arising for which appropriate conditioning measures are required. Another waste category are the disused sealed radioactive sources. If there is neither an option of returning them to the manufacturer nor the option of recycling, they are dedicated for disposal by the LSSt BW.

The sealed radioactive sources delivered to the LSSt BW are of different types and activities, e.g., smoke detectors arising from removal of old buildings, sources from research and test sources from measuring devices. Moreover, found objects, e.g., from entry controls on metal recycling and sources secured by administrative order are delivered to the LSSt BW. The sealed radioactive sources are only a small amount of the total volume delivered to the LSSt BW, but they cause a large amount of the total activity.

Between 2014 and 2016, a total of 350 sealed radioactive sources and over 1,000 sources doped with Ra-226 were delivered to the LSSt BW. Depending on the waste generated by the delivering party, the waste is delivered either as mixed waste, i.e. in press drums mixed with other solid, non-combustible waste or unmixed – packed by type, i.e. one single or up to 150 sealed radioactive sources per waste package. The sealed radioactive sources considered here can broadly be divided into five fractions: smoke detectors, electron capture detectors (ECD), found objects from entry controls on metal recycling, regulatory transfer and test sources.

There are various processes for the management of the different sealed radioactive sources, e.g., high-pressure compaction or embedding in fixing media. The aim of conditioning is to transform radioactive waste into a form that is suitable for disposal in the Konrad repository. Compliance with the boundary conditions specified by the legislator is required for all measures to be implemented. The implementation of these specifications is ensured by means of the process qualifications approved by the BGE. In a subsequent step, the products produced in these processes are packed up in appropriate packages for disposal and later transported to the federal disposal facility. All conditioning steps are documented in a system of waste management record keeping in order to ensure a comprehensive traceability of the waste. By means of these data, detailed disposal facility documentation is prepared which is submitted to authorized experts and to the BGE for examination.

As a rule, ionisation smoke detectors are sent completely, i.e. including plastic housing, for conditioning, as separating of the source is not economically feasible. The smoke detectors are already packed up into press drums by the waste producer. The subsequent conditioning is performed by means of high pressure compaction generating a volume optimised product. All ionisation smoke detectors delivered to the LSSt BW within the reporting period contain Am-241 sources.

The Ni-63 ECD originate from analytical laboratory operations of different group of companies from breweries to pharmaceutical companies. Also here, the actual source is delivered as a whole component and is then compacted under high pressure.

The sources found within the frame of entry controls at metal recycling companies are a further fraction. With two exceptions (Co-60 and Cs-137) in the last three years, these were only small-sized sources containing Ra-226. These findings are also delivered to the LSSt BW as compactable waste. A large-volume Co-60 source used in a fill level gauge including its shielded container found in the past, remained, so far, an individual case.

In addition to the above mentioned source types delivered almost continuously to the LSSt BW, there are also single deliveries taking place at irregular intervals but in relatively large volumes. These are e.g. collection campaigns or regulatory transfers. During the reporting period from 2014 until 2016, approx. 1,000 sources with Ra-226 were delivered for conditioning within a regulatory transfer. In cases where an unmixed delivery is not possible, a sorting prior to the actual conditioning process is taking place. In the course of this, e.g. combustible parts or packaging materials are separated. If necessary, dividing onto several press drums can take place during this processing step.

The disused sealed radioactive sources represent the largest fraction with the highest activity. Most of the mentioned test sources originate either from research, directly from the manufacturer or from the industry, e.g. from a measuring instruments manufacturer, but also from end-consumers, if there is no option for return to the respective manufacturer. Sources from schools arise only occasionally, as in the frame of a large-scale collection campaign initiated some years ago, many schools have submitted their sources.

The following figures show the different types of sealed radioactive sources with regard to their activity (Figure J-1) and their number (Figure J-2).

Figure J-1: Depiction of the sealed radioactive sources fractions depending on their activity

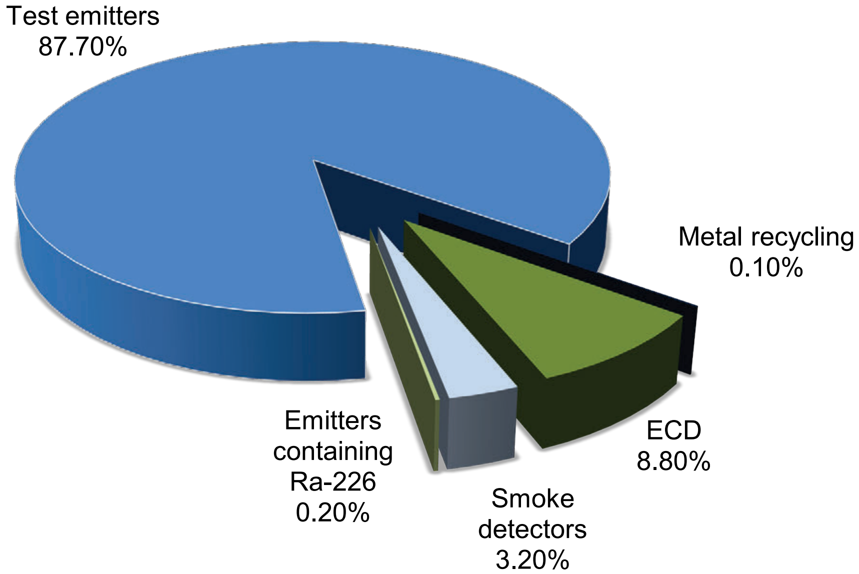
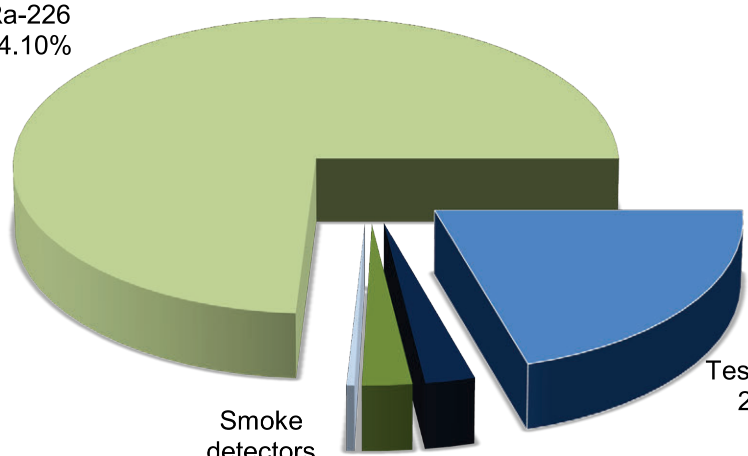


Figure J-2: Depiction of the sealed radioactive sources fractions depending on their number



Usually, disused test sources are also placed into press drums and delivered with the aim of compacting under high pressure. In case of delivery of several sources in one press drum, the prior consultation is necessary in order to ensure e.g. the compliance with activity limits (limit values in accordance with the waste acceptance requirements of the Konrad repository and also operational limits). In individual cases, dividing onto several press drums may be necessary.

During the reporting period, the dominating radionuclides of the test sources delivered were (starting with the highest activity and quantity): Cs-137, Am-241, Co-60 and Ra-226.

Land collecting facility of Saxony (LSSt Saxony)

In the *Land* collecting facility of Saxony, sealed radioactive sources in lead shielding are stored separately according to the deliverer's corresponding *Land* collecting facility number. Only sources with an updated leak-tightness proof and a source certificate are accepted for storage. The entry control includes a visual inspection by checking the source number indicated at the source certificate. During storage of the sources, leak-tightness has to be tested and proved by a direct or indirect contamination control every three years.

During the operating years, deliveries of sealed sources took place in highly varying numbers. Table J-2 shows deliveries of sealed radioactive sources from the commissioning of the *Land* collecting facility until the year 2016.

Table J-2: Deliveries of sealed radioactive sources to the *Land* collecting facility during the period of 1992 - 2016

Year of acceptance	Number of sources	Nuclides	Total activity sources [Bq]
1992	57	Sr-90; Kr-85	6.47E+10
1993	36	Sr-90; Cf-252; Am-241; Co-60	6.68E+10
1995	46	Sr-90; Cs-137; Am-242; Am/Be	1.04E+11
1996	119	Cs-137; H-3	1.68E+11
1997	122	Co-60; Cs-137; Am-241/Be;	3.32E+11

Year of acceptance	Number of sources	Nuclides	Total activity sources [Bq]
1998	178	Kr-85; H-3; Sr-90; Cs-137;	4.63E+11
1999	423	Cs-137; Co-60, Kr-85	5.37E+11
2000	396	H-3; Sr-90; Co-60; Cs-137; Am-241	6.21E+11
2001	77	Sr-90; Kr-85; Cs-137	7.83E+11
2002	209	Co-60; Sr-90; Cs-137; Am-241; Am-241/Be	9.93E+11
2003	76	Cf-252; Am-241; Sr-90;	1.04E+12
2004	24	Sr-90; Cs-137; Am-241; Am-241/Be	1.05E+12
2005	47	Cs-137; Am-241; Cf-252	1.07E+12
2006	111	Sr-90; Cs-137; Am-241	1.25E+12
2007	77	Sr-90; Cs-137; Am-241	1.43E+12
2008	116	Sr-90; Cs-137; Pu-239; Am-241/Be	1.43E+12
2009	67	Co-60; Cs-137; Am-241; Cf-252	1.48E+12
2010	155	Sr-90; Cs-137; Am-241	2.00E+12
2011	141	Kr-85; Co-60; Cs-137; Am-241/Be; Pu-238	3.94E+12
2012	66	Co-60; Kr-85; Cs-137; Am-241; Am-241/Be	2.40E+11
2013	49	Co-60; Kr-85; Sr-90; Po-210; Am-241	2.55E+11
2014	465	Co-60; Fe-55; Kr-85; Sr-90; Am-241; Ra-226/Be	3.49E+11
2015	71	Cs-137; Po-210; Pu-239	3.52E+11
2016	278	Co-60; Cs-137; Pu-239; Am-241/Be	3.10E+11

The relatively high number of deliveries until the year 2000 results from liquidations and modifications of companies due to the reunification.

In 2012, approx. 1,000 radioactive sources in 265 waste packages were transported from the LSSt for recycling. There was no return of waste and residues to the *Land* collecting facility. The waste volume arising from recycling was estimated to be less than 0.01 cubic metres. The sources remaining at the *Land* collecting facility were Am-241, Cf-252 and Kr-85 nuclides; they remained at the facility for transportation and licensing relevant reasons.

From 2012 to 2016, a total of 929 sealed radioactive sources in 75 waste packages were accepted for storage.

In 2016, 142 Kr-85 sources were delivered for recycling. Thus, there are currently no Kr-85 sources at the *Land* collecting facility Saxony.

The *Land* collecting facility still plans to recycle all sealed radioactive sources stored there.

Sealed radioactive sources at the Morsleben repository for radioactive waste (ERAM)

During the period from 1981 to 1998, a total of 6,621 sealed radioactive sources with a total activity of $1.0 \cdot 10^{13}$ Bq (last edited: 31 December 2016) were disposed of in the ERAM. These sealed radioactive sources are to be classified among the radioactive waste with negligible heat generation. Co-60, Cs-137, Sr-90, Eu-152, Ra-226, Kr-85, Ag-110m, Pm-147, Ir-192, Am-241 and Th-228 are the dominating radionuclides of these sealed radioactive sources.

Usually, the disposal of sealed radioactive sources was carried out by dumping of from reusable source containers in a working underneath and then backfilled with salt breeze. Furthermore, sealed radioactive sources were solidified. The waste packages with the solidified radioactive sources were disposed of by stacking.

By way of derogation from the dumping of, four Co-60 sources were emplaced in the 4a level, three of them in lead containers and one of them in a radiation head. This was necessary, as with regard to radiation protection aspects a reloading of the Co-60 sources from the containers or the radiation head was not justified.

Neutron sources were excluded from disposal.

For research purposes on the development of new disposal technology of higher-level sealed radioactive sources or solid waste with short-lived radionuclides (Co-60 and Cs-137, as well as waste containing europium), which are to be classified among heat generating radioactive waste, this waste was stored in seven special containers in a way that it can be retrieved since the 1980s. This waste, with a total activity of approx. $1.4 \cdot 10^{14}$ Bq (last edited: 31 December 2016), is placed in two boreholes in the underground measuring field on the 4th level. Within the frame of closure of the ERAM, these special containers are to be disposed of.

Due to a ministerial council decision in the 1960s, the use of Ra-226 sources was terminated as a result of the assessment of safety events with the Ra-226 radionuclide. From the mid-1960s, all sources were collected from the licence holders by employees of the State office for radiation protection (SZS, from August 1973: State board for atomic safety and radiation protection, SAAS). These sources, mostly sealed radioactive sources, were transported to the storage facility of SZS/SAAS in Lohmen and conditioned; the conditioned waste containing Ra-226 with an activity of $3.7 \cdot 10^{11}$ Bq (last edited: 31 December 2016) was placed in seven special containers into a drum and was stored there. When Lohmen was closed, this drum was transported to ERAM and is stored there in the underground measuring field on the 4th level in a way that it can be retrieved. This waste package with the conditioned Ra-226 waste, too, is to be disposed of within the frame of the closure of the ERAM applied for.

Regulations for discovery and loss

§ 71 StrlSchV [1A-8] regulates the loss, discovery and acquisition of actual control over radioactive material and is therefore also relevant for radioactive sources. Accordingly, any loss of actual control over radioactive material whose activity exceeds the exemption levels stipulated in Appendix III, Table 1, Columns 2 and 3 StrlSchV must be reported immediately to the competent nuclear supervisory authority or to the authority responsible for public safety and order by the owner of the material. Loss of a high-activity sealed radioactive source also requires immediate reporting to the register for high-activity sealed radioactive sources at the BfS in electronic form, using the standard record sheet specified in the StrlSchV (see details on the HASS register). Any discovery of radioactive material or acquisition of actual control over such material must be reported immediately to the competent nuclear supervisory authority or to the authority responsible for public safety and order.

In the vast majority of the very rare cases of so-called “orphan sources” in Germany, sealed radioactive sources of low activity are concerned. Loss and discovery of radioactive materials are regularly recorded in the annual reports of the BMUB [BfS 14a] and in parliamentary reports [BfS 14b]. In 2015, 66 found and 3 lost radioactive sources were registered in Germany. The publication of these reports has also the task to inform the public about this topic and to raise awareness about this subject area.

J.1.2 Re-entry of disused sources

In Germany, sealed radioactive sources are manufactured and also exported to other countries. Therefore, regulatory requirements for re-entry of disused sealed radioactive sources into Germany have existed for a long time. These regulations fully take into consideration the generally high risk potential of sealed radioactive sources and allow implementing the requirements of the Code of Conduct on the Safety and Security of Radioactive Sources [IAEA 04] which deals in §§ 23 to 29 with the import and export of sealed radioactive sources and demands a co-operation of the authorities involved in shipments (i.e. also in the re-entry) of similar extent and intensity as for shipment of radioactive waste. The regulations for transboundary movement contained in §§ 19 to 22 StrlSchV [1A-8] also apply to HASS.

It needs to be mentioned that shipment within the EU is not subject to licensing requirements and that, in addition, a licence for shipment from or into third country/countries may be replaced by a notification. Transboundary movement inside the EU is regulated by Council Regulation No. 1493/93/EURATOM [1F-34]. With respect to sealed radioactive sources, the prior notice of the competent authority based on a declaration of the addressee is essential (in Germany: the BAFA). The competent authority of the country of destination must also be notified of the completion of the shipment.

As far as a transboundary movement is subject to legal requirements for licensing or notification, e.g. for re-entry of a sealed radioactive source from a non-EU country, the competent authority according to § 22 AtG [1A-3] is the BAFA.

According to § 69(5) StrlSchV, high-activity sealed radioactive sources that are no longer used or for which no further use is intended shall be delivered to the manufacturer, the carrier or another licence holder after end of use or delivered as radioactive waste or kept in storage. Recycling of disused sealed radioactive sources after their return is also possible in principle, e.g. at the manufacturer's or by another authorised company possessing the requisite licence. The previous user is not allowed to keep a source without use. The manufacturer and the carrier of high-activity sealed radioactive sources are obliged to take back these sources or have to ensure that they are taken back by third parties, as outlined above.

According to § 19 StrlSchV, the transboundary movement of such sources is subject to licensing if the activity exceeds the 100-fold of the value specified in Appendix III, Table 1, Column 3a StrlSchV. If the activity remains below this value, shipment may take place under certain conditions within a notification procedure. For shipments of such sources from a state outside the EU to Germany, this is possible if the importing carrier

1. has taken precautions to ensure that after shipment, the delivered radioactive materials may only initially be bought by persons who hold the necessary licence according to §§ 6, 7 or 9 AtG or according to § 7(1) or § 11(2) StrlSchV, and
2. notifies this shipment to the competent authority as stipulated in § 22(1) AtG and delivers the notification to the regulatory body responsible for supervision as stipulated in § 22(2) AtG or to the body appointed by it in connection with customs clearance at the latest.

In the case of shipment of other radioactive material between EU Member States, the provisions of Council Regulation No. 1493/93/EURATOM [1F-34] apply, which stipulates the following for sealed sources:

> "(Article 4)
>
> (1) A holder of sealed sources […], who intends to carry out a shipment of such sources […], or to arrange for such a shipment to be carried out, shall obtain a prior written declaration by the consignee of the radioactive substances to the effect that the consignee

has complied, in the Member State of destination, with all applicable provisions implementing Article 3 of Directive 80/836/EURATOM and with relevant national requirements for safe storage, use or disposal of that class of source […].

The declaration shall be made by means of the standard documents set out in Annexes I and II to this Regulation.

(2) The declaration referred to in paragraph 1 shall be sent by the consignee to the competent authority of the Member State to which the shipment is to be made. The competent authority shall confirm with its stamp on the document that it has taken note of the declaration and the declaration shall then be sent by the consignee to the holder."

However, this is merely a statement of intent, which does not permit any control over shipments that have actually taken place, since the Regulation furthermore stipulates:

"(Article 5)

(1) The declaration referred to in Article 4 may refer to more than one shipment, provided that:

- the sealed sources […], to which it relates have essentially the same physical and chemical characteristics,
- the sealed sources […], to which it relates do not exceed the levels of activity set out in the declaration, and
- the shipments are to be made from the same holder to the same consignee and involve the same competent authorities.

(2) The declaration shall be valid for a period of not more than three years from the date of stamping by the competent authority as referred to in Article 4(2)."

A reporting system for realised shipments of radioactive materials is outlined below:

"(Article 6)

A holder of sealed sources [and] other relevant sources […] who has carried out a shipment of such sources or waste, or arranged for such a shipment to be carried out, shall, within 21 days of the end of each calendar quarter, provide the competent authorities in the Member State of destination with the following information in respect of deliveries during the quarter:

- names and addresses of consignees,
- the total activity per radionuclide delivered to each consignee and the number of such deliveries made,
- the highest single quantity of each radionuclide delivered to each consignee,
- the type of substance: sealed source, other relevant source […]."

As a result of this reporting procedure, it is evident that the competent authorities in each EU Member State (in Germany, the BAFA) only receive data about shipments into their country on a quarterly basis, the completeness of which cannot otherwise be verified. There is no provision under this Regulation for reports regarding shipments from one country to another EU Member State. In order to fill this loophole, Germany has submitted a proposal to the European Commission outlining the need, among others, to report to the authority of the delivering country as well. The relevant proposals have been reiterated and put up for discussion by a German representative at a meeting in Brussels in 2013 to review the results achieved so far by the Council Regulation No. 1493/93/EURATOM.

J.1.3 International aspects

The German regulations take into account the fact that the safety and security of sealed radioactive sources has a strong international dimension. Of particular importance in this connection are orphan sources, as the global scrap trade contributes to their unintended spread. Sealed radioactive sources hidden in scrap present a much higher potential risk than contaminations with naturally occurring radioactive material (NORM) or other radioactive materials. Therefore, Germany welcomes all efforts aimed to reduce the potential risk and especially to prevent the spread of sealed radioactive sources in the global scrap trade.

Examples:

- the information system operated by the IAEA for transmission of data about loss of sealed radioactive sources worldwide,
- organisation of international meetings and other forums for information exchange between experts at the international level, as for example the International Conference on Control and Management of Inadvertent Radioactive Material in Scrap Metal in Tarragona (Spain) in February 2009, as this may lead to coordinated and harmonised international strategies,
- development of an international convention regarding the transboundary shipment of scrap and semi-finished products (Code of Conduct on the Transboundary Movement of Radioactive Material Inadvertently Incorporated into Scrap Metal and Semi-finished Products of the Metal Recycling Industries) under the auspices of the IAEA which is being prepared at the moment under leadership of the IAEA [IAEA 14], whose adoption, however, failed due the lack of consensus of the Member States,
- the efforts of individual countries in creating particularly open regulations for accepting the costs for the management of sealed radioactive sources discovered in scrap to ensure that discoveries are reported to the authorities and not suppressed in fear of high disposal costs. In Spain, for example, this has been realised by means of the “Spanish Protocol” whose approach has also been adopted by South American countries.

The final report of the conference in Tarragona in 2009 expresses that, by the adoption of a binding convention between the states, a standardisation of the approach to prevent unintended transboundary movement of radioactive material contained in scrap could be achieved. This concern is reflected in the drafting of the international convention referred to.

The international data exchange facilitates the worldwide control and tracking of sealed radioactive sources. Within the EU, important prerequisites regarding the international data exchange are fulfilled by the abovementioned rules, in particular Council Regulation No. 1493/93/EURATOM [1F-34] and Council Directive 2003/122/EURATOM [1F-22]. Agreements on an electronic data exchange format as well as the consideration of experiences of the Member States of the European Union are relevant objectives in the future.

Germany is actively involved in improving the safety of the sealed radioactive sources management, also in different countries. Thus, in the Ukraine with German support, in the frame of bilateral projects, it was possible to achieve that a large number of sealed radioactive sources, approx. 15,000, were recorded and safely stored with regard to radiation and physical protection aspects. Furthermore, modernisation measures at technical installations for the handling of sealed radioactive sources were carried out and the required transportation and storage containers were provided.

Based on the findings and the experiences gained, Germany is planning further bilateral technical assistance programmes. These programmes may refer to the documentation of the disused sealed radioactive sources or to the development of concepts on their safe central storage.

K General efforts to improve safety

This section summarises the progress made by Germany so far to improve safety since the Fifth Review Meeting in 2015 and explains the implementation of the Repository Site Selection Act as well as the measures to secure financing and implementation of the management of spent fuel and radioactive waste. In addition, this section deals with the efforts undertaken to ensure safety in connection with the handling and management of spent fuel and radioactive waste by applying and further developing safety standards, as well as the planned review of the national supervisory authority with the inclusion of integrated review services of the International Atomic Energy Agency (IAEA).

K.1 State of affairs regarding challenges and planned measures to improve safety according to the Rapporteur's report relating to the German presentation during the Fifth Review Meeting

The Rapporteur's report to the Fifth Review Meeting in 2015 summarises the challenges still ahead as well as the planned measures to improve safety which were identified by the Country Group as a result of the German presentation. The progress made regarding these items during the period under review is set out below.

(1) Challenges

Implementation of the recommendations of the Commission on the Storage of High-Level Radioactive Waste for the site selection procedure and the associated public participation

In July 2016, the Commission on the Storage of High-Level Radioactive Waste presented its final report [KOM 16]. In order to implement the recommendations of the Commission, the *Bundestag* and the *Bundesrat* adopted the Act Amending the Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste and for the Amendment of Other Laws [1A-7b], which largely entered into force on 16 May 2017. The resulting developments are described in detail in Chapter K.2.

Establishment of a licensed condition with respect to the storage of spent fuel in the AVR cask storage facility in Jülich

As regards the storage facility in Jülich, the licensing procedure for extended storage could not be completed by 31 July 2014. Thus, on 2 July 2014, the then Ministry of Economic Affairs, Energy, Industry, SMEs and Crafts of North Rhine-Westphalia (MWEIMH) issued an order for the removal of the AVR casks from the storage facility. The Forschungszentrum Jülich, which was responsible at that time (now Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH – JEN), presented a concept for the removal of the AVR casks from the storage facility in autumn 2014. Three options are considered for the removal of nuclear fuel (fuel spheres):

Option 1: Transport of the fuel spheres to the Ahaus transport cask storage facility

The licensing procedure for the transport of the fuel spheres to Ahaus for storage was resumed in January 2015. On 21 July 2016, the 8th modification licence for the Ahaus transport cask storage facility was granted by the Federal Office for Radiation Protection (BfS). The licence for the transport of the fuel spheres to the Ahaus transport cask storage facility is still pending. When the granting of this licence can be expected is still unknown.

Option 2: Shipment of the fuel spheres to the United States of America

The option of shipment of the fuel spheres to the United States of America has been examined since mid-2012. The U.S. Department of Energy had signalled its willingness to return the nuclear fuel provided for research purposes to the United States of America. The spent fuel spheres are no radioactive waste from a commercial nuclear power plant, but recyclable residues from a test and demonstration reactor. In accordance with applicable law, this spent nuclear fuel from research reactors can be returned to the country of origin if, on the one hand, agreement is reached between the responsible actors. On the other hand, the conditions for the export of nuclear fuel (§ 3(6) of the Atomic Energy Act (AtG) [1A-3]) must be observed, which became effective on 16 May 2017 with the Act Amending the Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste and for the Amendment of Other Laws.

Furthermore, a corresponding contract can only be concluded if the necessary conditions for acceptance have been created at the destination of shipment of the fuel spheres. Besides the clarification of numerous technical questions, an environmental impact assessment is currently taking place in the United States of America. Only after that it will be clear whether the fastest way to remove the AVR fuel spheres can be achieved by shipment to the United States of America.

Option 3: Construction of a new storage facility in Jülich designed against earthquake

The construction of a new storage facility for the fuel spheres in Jülich would probably take the longest. Nevertheless, the previously suspended licensing procedure was resumed in 2012 and has been continued since then. For the construction of a new storage facility in Jülich, proof of seismic qualification of the existing AVR cask storage facility is mandatory. This would be a prerequisite for further storage of the fuel spheres in the existing storage facility until a new building could be put into operation. Investigations on the earthquake resistance continue to take place.

Until final clarification as to which of the three options is to be implemented, JEN's objective as the owner of the AVR fuel spheres is to keep all options open and to further specify them. The actual decision on the continued storage of the AVR fuel is made by JEN in close coordination with the MWIDE as the competent nuclear supervisory authority.

Establishment of a licensed condition with respect to the storage of spent fuel in the on-site storage facility Brunsbüttel

As regards the Brunsbüttel on-site storage facility, the judgement of the Higher Administrative Court of 19 June 2013 has become final with the decision of the Federal Administrative Court of 8 January 2015 and thus the storage licence for the Brunsbüttel storage facility is revoked. The nine casks stored there will be stored in the on-site storage facility by order of the Ministry of Energy Transition, Agriculture, the Environment and Rural Areas Schleswig-Holstein of 16 January 2015 according to § 19(3) AtG. The ordered storage is limited to the duration of a licensing procedure, but not later than January 2018. Emplacement of the fuel assemblies in the reactor pressure vessel into storage casks and transfer to the storage facility still takes place. On 16 November 2015, the Kernkraftwerk Brunsbüttel GmbH & Co. oHG filed an application for a new licence according to § 6 AtG for the storage of the nuclear fuel in the existing on-site storage facility at Brunsbüttel. In the course of the licensing procedure, the Federal Office for the Safety of Nuclear Waste Management (BfE) has to carry out an environmental impact assessment.

Return of the radioactive waste from reprocessing in France and in the United Kingdom

On 19 June 2015, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) presented an overall concept to initiate the return of vitrified radioactive waste from reprocessing in France and in the United Kingdom within an appropriate time frame. The concept envisages the storage of the five casks with vitrified intermediate level waste from France at the Philippsburg on-site storage facility. The 21 casks with vitrified high level waste from the United Kingdom are to be distributed to the on-site storage facilities Biblis, Brokdorf and Isar. The return is to take place successively. According to current plans, the five casks from France are expected to be returned in 2019. From 2019 to 2021 21 casks are to be returned from the United Kingdom in three transports. Corresponding storage licences and transport permits must be applied for by the electric power utilities (EVU).

Extended storage of spent fuel and radioactive waste from reprocessing

A disposal facility for heat-generating radioactive waste is expected to be operational by 2050. Until commissioning of the disposal facility, the spent fuel and heat-generating radioactive waste from reprocessing shall be kept at the existing storage facility sites. The storage licences for these storage facilities are limited to 40 years starting from the first emplacement of a transport and storage cask and expire between 2034 and 2047. An extension of the storage period will thus be necessary, but should be limited to the absolutely necessary period. As stipulated in § 6(5) AtG, a licence may only be renewed on imperative grounds and after this issue has been discussed in the German *Bundestag*.

Against this background, the Nuclear Waste Management Commission (ESK) is addressing a number of safety-related issues in its “Discussion paper on the extended storage of spent fuel and other heat-generating radioactive waste” [4-20]. For an extended storage, safety proofs are to be furnished for casks and inventories, based on systematic analyses and reliable data. For this purpose, evaluations from operating experience can be referred to, including ageing management and periodic safety reviews, as well as additional investigation programmes on the long-term behaviour of cask components and inventories.

Operating experience combined with regular safety reviews and systematic ageing management measures do not indicate any deterioration of the relevant safety functions. Irrespective of this, there are a number of questions to be clarified with regard to the extended storage and the subsequent waste management steps. In order to answer these questions, the BMUB supports national research projects and promotes the participation and cooperation of specialised organisations, which contribute to its tasks in international organisations on its behalf and address new aspects related to storage and promote the exchange of experience.

Closure of the ERAM, commissioning of the Konrad repository

The BfS, which was responsible for the closure of the repository for radioactive waste Morsleben (ERAM) until April 2017, has developed a closure concept based on extensive investigation programs. This concept provides for an almost complete backfilling of the mine, sealing of the emplacement areas and sealing of the shafts. The planning documents for closure also included a long-term safety case. On 31 January 2013, the ESK submitted the statement “Long-term safety case for the Morsleben repository for radioactive waste (ERAM)" [4-11a], which was commissioned by the BMUB. In this statement, the ESK concludes that the long-term safety considerations of the BfS should be adapted to the state of the art in science and technology. The implementation of the ESK recommendations requires additional proofs and a revision of the application documents.

Up to now, the company Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH (DBE), commissioned by the BfS, carried out the conversion of the Konrad mine to a repository. In the future, the Bundes-Gesellschaft für Endlagerung mbH (BGE) will be competent for it, into which, among others, also the DBE will be merged. The necessary refurbishment of the shafts is continued. Work on the underground strengthening of galleries and driving of the infrastructure galleries are currently underway. Furthermore, work started to drive mine workings for the processing of backfill material. The aim is to complete the construction of the repository as soon as possible and to put it into operation by September 2022 at the latest.

Management of decommissioning waste of the nuclear power plants

With the Thirteenth Amendment to the Atomic Energy Act [1A-25], the authorisation for power operation expired for eight German nuclear power plants. On 27 June 2015, the Grafenrheinfeld nuclear power plant was permanently shut down, too. All nine nuclear power plants, which were shut down until then, have meanwhile applied for a decommissioning licence. For Isar 1, Neckarwestheim I, Biblis Unit A and Unit B as well as Philippsburg 1, the decommissioning licence has already been granted (see Table L-14). This results in the need to carry out several large decommissioning projects in parallel and at the same time. In Germany, there is extensive experience from ongoing and completed decommissioning projects available. The licensing procedures for their implementation are fully regulated in the Atomic Energy Act and the related ordinances.

When the application documents were prepared, the residues and waste from dismantling were also considered. The residues and waste from decommissioning must be treated. To this end, proven procedures and proven mobile or stationary installations are available at the nuclear power plant site or external installations. In order to reduce the need for storage and disposal volumes, special treatment methods for volume reduction are used for some waste types, such as compaction, melting or incineration, for which existing external facilities are used. After successful treatment, the resulting residues are returned to the site. In addition to the use of existing facilities and reclassification of rooms and plant areas within the nuclear power plant, the establishment of new treatment centres and storage facilities is also planned plant-specifically for the provision of the necessary treatment and storage capacities. At the sites Neckarwestheim, Philippsburg, Grafenrheinfeld, Biblis, Unterweser and Brunsbüttel, corresponding licences according to § 7 of the Radiation Protection Ordinance (StrlSchV) were applied for and some of them already granted. It is planned to store the conditioned radioactive waste at the site until it can be transferred to the Konrad repository.

Retrieval of the radioactive waste from the Asse II mine

With the entry into force of the “Lex Asse" [1A-26], justifications with respect to individual measures or closure variants are no longer required. Against this background, the President of the BfS commissioned the evaluation of the fact finding and the procedure for retrieval.

As a result of the evaluation, the first step of the fact finding (the drilling into two selected chambers), is to be continued and completed as planned. However, it was proposed to dispense with the second and third step of the originally planned fact finding (opening and recovery on a trial basis) and, instead, start retrieval from chambers for which atmosphere and local rock conditions are known. Corresponding work on concept planning was started. The experience gained can then be used for retrieval from sealed and completely backfilled chambers (principle: proceeding from simple to complex).

A new shaft, new underground infrastructure rooms as well as conditioning capacities and a storage facility are required to recover the radioactive waste. The salt structure is currently being explored with regard to the underground infrastructure rooms and the planned emplacement areas of a new shaft site. For this purpose various drillings were carried out underground and at the surface. An assessment has shown that the results so far do not reveal any findings that would jeopardise the realisation at the planned site. The planned exploration for shaft and infrastructure at the site east of the mine building will therefore be continued. For the underground exploration of the shaft site investigated, at least three further drillings must be carried out. From today's point of view, a decision about whether a shaft can be built at the currently investigated site can be made at the beginning of 2019.

In parallel, the operator ((BGE) carries out consequence analyses which are intended to assess the radiological consequences if a beyond-design-basis inflow of solutions occurs before retrieval of the waste and, as a consequence, the waste or parts of the waste have to remain in the mine.

(2) Planned measures to improve safety

Implementation of the national waste management programme according to Council Directive 2011/70/EURATOM

On 19 July 2011, the Council of the European Union adopted Council Directive 2011/70/EURATOM [1F-36], which requires the Member States to establish a national framework of legislation, execution and organisation for the responsible and safe management of spent fuel and radioactive waste. This includes, among other things, the duty of the member states to draw up a national waste management programme, which must be regularly reviewed and updated, taking into account technical and scientific progress as appropriate. The national waste management programme of the Federal Republic of Germany (Programme for the responsible and safe management of spent fuel and radioactive waste – National Programme) was submitted as scheduled in summer 2015.

On 26 November 2015, the Fourteenth Amendment to the Atomic Energy Act of 20 November 2015 [1A-28] entered into force. Primarily, the Act has transposed the duties directed to the operators of radioactive waste management facilities – including disposal facilities – into national law. Furthermore, the Act contains the standardisation of the obligation of the states to draw up a national waste management programme [BMUB 15].

Expansion of storage capacities in the course of the decommissioning projects as required

The decommissioning of nuclear facilities will partly require the expansion of on-site storage capacities. The measures envisaged for this can be found in the above section entitled "Management of decommissioning waste from the nuclear power plants".

Implementation of the Repository Site Selection Act starting with further surface and underground explorations for a deep geological repository for high level waste

The Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste and for the Amendment of Other Laws entered into force on 27 July 2013 [1A-7a]. On 16 May 2017, the Act Amending the Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste and for the Amendment of Other Laws [1A-7b] largely entered into force. The measures for implementing this Act are described in detail in Chapter K.2.

K.2 Implementation of the Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste

For the selection of a repository site for heat-generating radioactive waste, the Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste and for the Amendment of Other Laws (Repository Site Selection Act – StandAG) [1A-7a]) was adopted, which entered into force on 27 July 2013.

In May 2014, the Commission on the Storage of High-Level Radioactive Waste was convened on the basis of the StandAG to prepare the site selection procedure. In July 2016, after two and a half years of work, the Commission published its final report [KOM 16], which is addressed several times in this report.

In its report, the Commission recommends disposal of the waste in deep geological formations. For the selection of the repository site, the Commission recommends geoscientific and subsequent to it planning science criteria as well as the conduct of preliminary safety analyses. It is also recommended to include provisions for corrective actions, such as retrievability and recoverability. A site is to be determined in a multi-phase comparative procedure which ensures "best-possible safety" for the permanent protection of man and the environment against ionising radiation and other harmful effects of this waste for a period of one million years. It is determined by a decision of the German *Bundestag*. The recommendations of the Commission were implemented in i.a. the Act Amending the Act on the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste and for the Amendment of Other Laws [1A-7b], which largely entered into force on 16 May 2017. Several changes have been made to the version of the Repository Site Selection Act of 27 July 2013 (see details on the Repository Site Selection Act in Chapter E.2.2).

By the establishment of the Federal Office for the Safety of Nuclear Waste Management (BfE) and the Bundes-Gesellschaft für Endlagerung mbH (BGE), a reorganisation of the organisational structure has already been implemented at the legislative level [1A-30]. This new structure of the licensing and supervisory authority on the one hand and the project implementers on the other hand is currently under development.

In the site selection procedure, the BfE has, in particular, the tasks of defining exploration programmes proposed by the project implementer and associated test criteria, examining the proposals of the project implementer to narrow the areas that can be taken into consideration on a step-by-step basis, reviewing the final site proposal and developing well-founded recommendations. It monitors the enforcement of the site selection procedure and is the organiser and coordinator of public participation. It also plays an essential role in the safeguarding of areas potentially suitable for disposal. Upon completion of the site selection procedure, it will be responsible for the subsequent nuclear licensing procedure for the construction, operation and closure of the repository.

The publicly owned BGE is the project implementer and has the task of implementing the site selection procedure. In the procedure to be performed on a step-by-step basis, the project implementer will first identify areas with favourable geological conditions, develop proposals for the sites to be explored, explore these by means of exploration programmes and test criteria agreed upon with the BfE, and prepare the respective preliminary safety investigations. The BGE is committed to transparent information of the public on its work.

As a result of the site selection procedure, the project implementer BGE proposes a site for the future repository. The proposal has to be examined by the BfE. The site decision is then made by means of a legislative procedure by federal law.

Early and comprehensive public participation is of paramount importance in the site selection procedure. The provision of information in the depth required and in an easily understandable manner as well as transparency in all steps of the procedure are basic prerequisites on the part of the licensing and supervisory authority and the project implementer to enable dealing with the procedure and participating in the processes for the broadest possible public interested in it. For the involvement of the public, bodies are set up at the national and regional level that are independent of authorities and project implementer and equipped with the necessary resources.

At the national level, the National Advisory Board to accompany the site selection procedure (*Nationales Begleitgremium*) was formed in December 2016 as an independent public institution to accompany the selection procedure with commitment to the public welfare. In accordance with legal requirements, it accompanies the selection procedure and, in particular, public participation with the aim of enabling trust in the execution of the procedure.

At the regional level, regional conferences are convened as soon as the project implementer suggests site regions for exploration. At these conferences, concerned citizens and representatives of the municipal authorities concerned will be able to participate in the process of site selection. The regional conferences are given an opportunity of cross-regional exchanges through the "Council of the Regions" expert conference, involving stakeholders from the current storage facility sites.

After the implementation of the recommendations of the Commission on the Storage of High-Level Radioactive Waste, reorganisation of the organisational structure and amendment of the StandAG the site selection procedure can start. Due to the newly created possibilities for public participation and the obligation of the parties involved in the process towards transparency and dialogue, the procedure assumes a pioneering role in terms of public participation in long-term processes and strong public concern.

According to §§ 12 et seq. StandAG, the site selection procedure should in principle be reversible, i.e. the possibility of reversal in the current procedure shall be given to enable error corrections. The possibility of retrieval of waste during operation and temporary recoverability after sealing of the repository shall also be possible.

Important milestones, such as the decision on the selection of exploration sites for surface and subsequent underground exploration as well as the final decision on the site are determined by federal laws. The site decided on in the end as a result of the site selection procedure must be expected to ensure that the necessary precautions have been taken in the light of the state of the art of science and technology to prevent damage resulting from the construction, operation and closure of the disposal facility according to § 9b(1a) of the Atomic Energy Act (AtG) and that it does not conflict with other provisions of public law. When weighing, all public and private interests must be taken into account. The site decision is binding for the subsequent licensing procedure for the construction, operation and closure of the disposal facility.

The planned steps in the realisation of a geological disposal for heat-generating radioactive waste are shown in Figure K-1 and Figure K-2.

Figure K-1: Steps in the site selection for a repository for heat-generating radioactive waste, including responsibilities

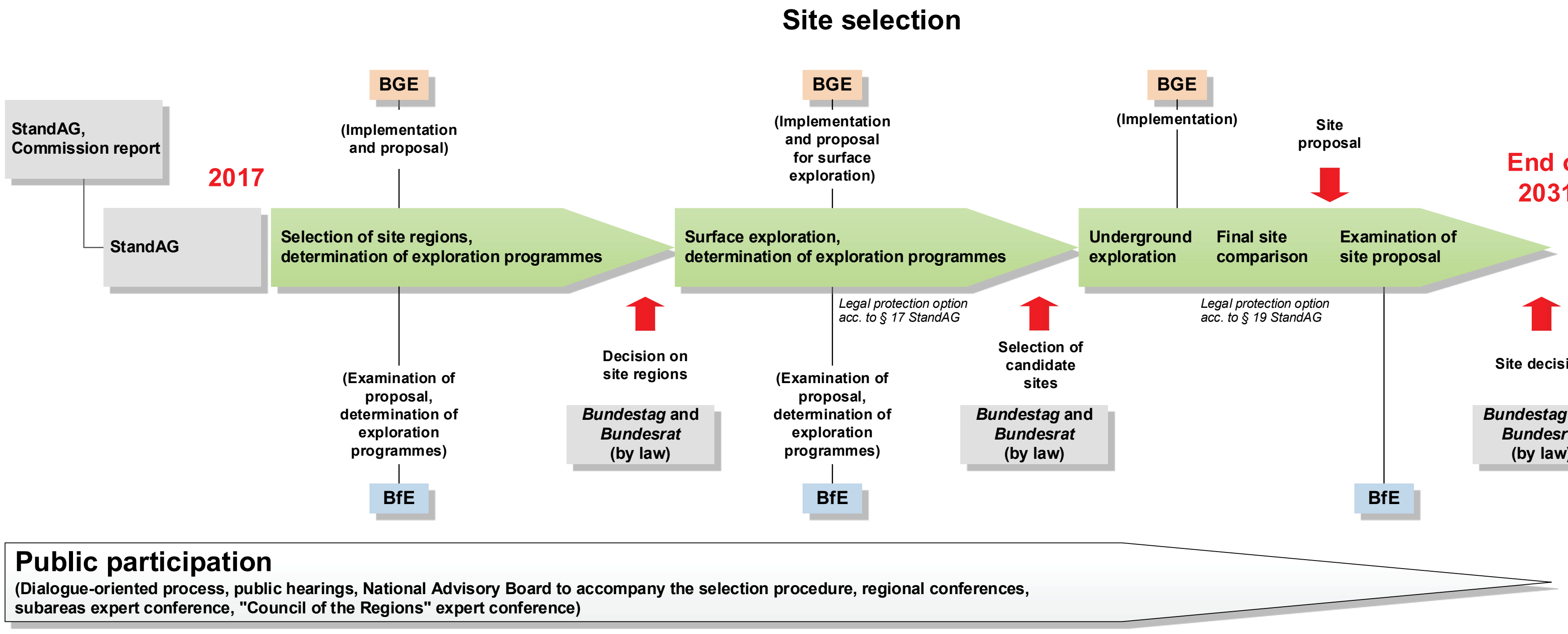
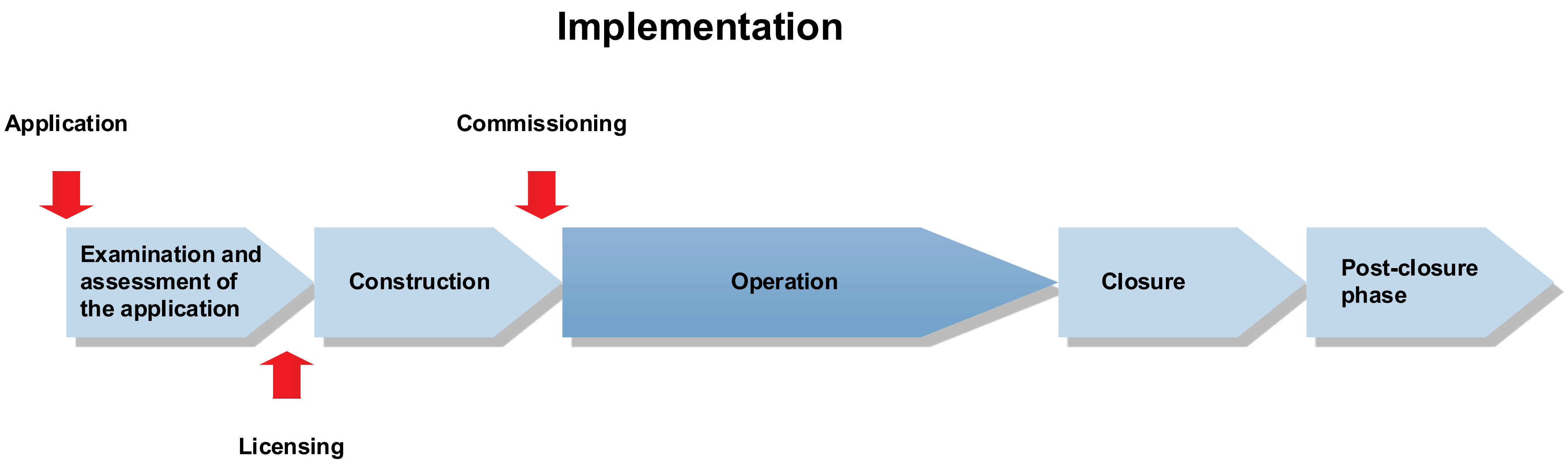


Figure K-2: Steps in the implementation of a repository for heat-generating radioactive waste



K.3 Issues relating to an extended storage of spent fuel and heat-generating waste

In Germany, spent fuel and heat-generating radioactive waste are kept in dry storage until they are delivered to a disposal facility. The storage licences for the storage facilities are currently limited to 40 years and expire between 2034 and 2047, but commissioning of a disposal facility is not expected before 2050. Against this background, it will be necessary to extend the licensed storage period. In § 6(5), the Atomic Energy Act (AtG) subjects the renewal of storage licences to the existence of imperative ground and requires prior referral to the German *Bundestag*.

The safety proofs for casks and inventories required for extended storage as well as for the maintenance of operational safety are to be furnished on the basis of sufficiently reliable data and knowledge to be assessed by the competent authorities and their experts. Furthermore, in the case of extended storage, the transportability of the casks must be ensured at all times during the entire storage period.

The long-term behaviour of casks, in particular their safety-relevant components, and of fuel assemblies as well as the degradation phenomena to be postulated and their impacts on safety are the main focus of the safety assessments for extended storage periods.

As the supreme supervisory authority, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) has initiated projects by way of precaution in which basic information and data on national and international experience are compiled in order to assess the safety issues related to the extended storage of fuel assemblies at an early stage and to be able to make competent assessments of corresponding concepts and strategies for their future storage. At present, there is the expectation that the currently established concept of dry storage (storage buildings and casks) maintains its safety functions even for considerably longer periods of time than 40 years. This assumption has to be confirmed by an explicit proof according to the state of the art in science and technology.

The additional data required for this can be generated both from the systematic evaluation of operating experience of the facilities operated to date during storage within the scope of a periodic safety review (PSR) and aging management, as well as from additional investigation programmes.

Technical ageing management focuses on the long-term behaviour of casks and inventories. It is to be demonstrated that the safety-relevant components remain intact also in the case of possible ageing-induced changes in properties during the entire storage period in such a way that they can fulfil their functions postulated in the safety analyses. With a view to non-technical ageing management, organisational structure, safety management as well as knowledge and quality management must also be considered. In addition, the changing framework conditions, such as the transition of the decentralised storage facilities to self-sufficient operation with the progressive dismantling of the nuclear power plants, must also be taken into account.

In its final report, the Commission on the Storage of High-Level Radioactive Waste explicitly emphasised the future need for research concerning extended storage. In addition to the safety proofs for casks and inventories, this also includes investigations on their long-term behaviour. The Commission sees a further research focus in the investigation of social-science and socio-technical aspects. It is planned to implement the recommendations for action through national research programmes.

At the international level, the issue of inaccessible cask components and inventories is being pursued together with the International Atomic Energy Agency (IAEA) through strategic and targeted research and development activities, particularly by the American side (US-NRC, EPRI, US-DOE). When evaluating international findings and data, the transferability to the German storage systems, including cask inventories, is to be examined in particular with regard to the specific boundary conditions in Germany.

K.4 Securing long-term financing and implementation of waste management

The authorisation for power operation of the nuclear power plants in Germany will expire at the end of 2022 at the latest. The nuclear power plants will then be decommissioned and dismantled. According to the polluter-pays principle, operators of nuclear power plants are obligated under the Atomic Energy Act to bear the costs for the decommissioning and dismantling of nuclear power plants as well as for the management of the radioactive waste they generate.

On 16 June 2017, the Act on the Reorganisation of Responsibility in Nuclear Waste Management [1A-31] entered into force after state aid approval by the European Commission (see Chapter E.2.2). It regulates the responsibility for nuclear waste management and secures the financing of decommissioning, dismantling and waste management in the long term without having to pass on the costs incurred for this purpose unilaterally to society or to jeopardise the economic situation of the operators.

In addition to transferring the financial means for storage and disposal into a fund for the financing of nuclear waste management by the operators – established with entry into force of the Act in the legal form of a foundation – Article 2 of the Act also includes the Act regulating the transfer of financing and action obligations for the management of radioactive waste from operators of nuclear power plants (Waste Management Transfer Act).

The Waste Management Transfer Act regulates the transfer of financing responsibility for storage and disposal from the operators to the fund. Accordingly, the financing obligation of the respective operator shall be transferred to the fund after the operator has provided the payment for the fund intended for this purpose in accordance with the Waste Management Fund Act. For the purpose of organising the storage of spent fuel and radioactive waste from the operation and decommissioning of nuclear power plants, a publicly owned storage company was founded under private law to which the storage facilities of the operators defined in the Act will be transferred with effect from 1 January 2019 (storage facilities with a licence according to § 6 of the Atomic Energy Act (AtG)) and with effect from 1 January 2020 (some storage facilities for radioactive waste with negligible heat generation). In the storage facilities for radioactive waste with negligible heat generation, both properly packaged (product-controlled) waste as well as waste not yet properly packaged can be stored. The operators transfer the properly packaged waste to the Federation, while the waste not properly packaged remains the property of the operators. This "mixed storage" ensures that risks are minimised by means of clear requirements as to the manner of storage as well as the further handling of waste which has not yet been properly packaged. The operators remain fully responsible for waste which has not yet been properly packaged.

The implementation of the Act is accompanied by a public-law agreement between the electric power utilities and the Federal Republic of Germany, which essentially specifies the legal regulations.

K.5 Western European Nuclear Regulators Association – WENRA – Harmonised approaches in the European nuclear regulatory frameworks in the areas of storage, decommissioning, disposal and waste treatment and conditioning

The objective of WENRA and its currently 18 member states is the joint development of safety standards in nuclear technology and their regulatory implementation at a national level.

This further development is to be carried out in terms of comparing general national regulations with the safety reference levels developed by WENRA. The aim is to harmonise the general regulatory safety approach of the individual member states through the establishment of safety standards that are mainly based on International Atomic Energy Agency (IAEA) requirements. All WENRA member states have committed themselves to do so. This is intended to ensure that the national regulations of all WENRA member states will arrive at a consistently high level of safety in the coming years.

WENRA has entrusted working groups with the implementation of the defined objectives which are composed of representatives of the national supervisory authorities. The Reactor Harmonisation Working Group (RHWG) is concerned with regulatory issues concerning the safe operation of nuclear power plants. The safety aspects of the nuclear fuel cycle at the back end are dealt with by the Working Group on Waste and Decommissioning (WGWD). The results of the working groups are subject to ratification by WENRA and are considered as adopted only after such ratification. They thus become binding for the member states of WENRA under the terms of self-commitment.

The work of the WGWD is divided into four areas: decommissioning of nuclear facilities, as well as processing, storage and disposal of spent fuel and radioactive waste. For these topics, requirements are developed in the form of safety reference levels according to international standards and the state of the art in science and technology. These are the basis for the subsequent review of the national regulations of the member states. If it is recognised that individual requirements are not explicitly covered by the national regulations, the WGWD accompanies and assesses the changes in regulations made at national level. The entire process from the development of the safety reference levels to the implementation in the national regulations of the member states is documented and published in the form of a written report by WENRA.

The following WGWD reports are currently available:

- “Decommissioning Safety Reference Levels Report” – Version 2.2 of April 2015 [WENRA 15],
- “Waste and Spent Fuel Storage Safety Reference Levels Report” – Version 2.2 of April 2014 [WENRA 14a],
- “Radioactive Waste Disposal Facilities Safety Reference Levels Report” of December 2014 [WENRA 14b],
- “Radioactive Waste Treatment and Conditioning Safety Reference Levels Report” of October 2016 [WENRA 16].

The harmonisation of the national regulations of the member states has been concluded for the topics of decommissioning and storage; the topic of disposal is currently under review of national regulations. Since 2014, the WGWD has been dealing with the topic of waste processing. The

"Radioactive Waste Treatment and Conditioning Safety Reference Levels Report" [WENRA 16] of October 2016 was adopted and published by WENRA.

Review of the German regulations

The review of the regulations relating to decommissioning in terms of the safety reference levels in Version 2.2 [WENRA 15] showed relevant deviations for four of the 62 safety reference levels. This concerns two safety reference levels each in the requirement areas "decommissioning strategy and planning" and "safety aspects". There is no deviation regarding the implementation of the requirements in practice. Compliance with the requirements of the safety reference levels as to the content is ensured by the system of regulatory supervision.

As regards storage, the Federal Republic of Germany fulfils all safety requirements of WENRA.

The national self-assessment of the German regulations on disposal was prepared on the basis of the corresponding report [WENRA 14b] and submitted to the WGWD for evaluation in February 2017. The discussion of the German disposal self-assessment was started at the WGWD meeting in February.

As regards waste processing, the first set of safety reference levels is available. It was published in October 2016 and is open for comments by stakeholders until 30 April 2017. This set of safety reference levels serves as the basis for the current review of the German regulations. The actual review has started in 2017 after the publication of the report, taking into account the comments by stakeholders.

K.6 Peer reviews (IRRS, ARTEMIS)

Regarding the obligation to carry out international reviews, as it results from the requirements of Directives 2011/70/EURATOM [1F-36] and 2014/87/EURATOM [1F-5], it is planned to carry out a review in the Federal Republic of Germany in 2019, involving the Integrated Regulatory Review Service (so called IRRS mission) and another one involving the Radioactive Waste Management Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation Programmes (ARTEMIS) of the International Atomic Energy Agency (IAEA). These review missions will examine the extent to which the national approaches are consistent with the IAEA safety standards and the technical guidelines as well as with international best practices.

IRRS mission

The IAEA organises reviews of the national nuclear regulatory authorities ("Safety Review Services") at the invitation of a member state. This IRRS was established by the member states of the IAEA as a lesson learnt from the Chernobyl accident for mutual assurance that effective monitoring of the use of nuclear energy is taking place. An IRRS mission already took place in September 2008 at the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and the Ministry of the Environment of Baden-Wuerttemberg at the invitation of the Federal Government, which was limited to the safety of the nuclear power plants. The topic of waste management was therefore not dealt with at this time. As a result of this mission, a total of 13 recommendations and 34 suggestions were formulated by the IAEA in addition to the listing of good practices. The implementation of the recommendations and suggestions was evaluated in September 2011 in a follow-up mission.

A full-scope IRRS mission is planned to take place at the BMUB and the *Länder* in 2019, also covering a comprehensive assessment of the current German regulatory framework for nuclear safety and radiation protection, including the regulations on the management of spent fuel and radioactive waste. The self-assessment of the Federal Republic of Germany and the preparation of the Advance Reference Material (ARM) are currently under way for this review mission. In addition to the self-assessment in terms of the IAEA safety requirements, the ARM will include further information such as, for example, a compilation of the relevant laws and regulations as well as documents on the organisation and working methods of the competent authorities.

ARTEMIS mission

The Radioactive Waste Management Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation Programmes (ARTEMIS mission), which is also carried out by the IAEA, is intended to review the entire German approach to the management of spent fuel and radioactive waste. In addition to the implementation of the National Programme for spent fuel and radioactive waste management and the legal framework, the existing regulations and their implementation regarding waste processing, storage and disposal, control of discharges from nuclear facilities, decommissioning of nuclear facilities and the remediation of contaminated sites are also expected to be assessed. Thus, the ARTEMIS mission addresses the competent authorities and organisations, the decision-makers of the national waste management policy, but also the operators of waste management facilities.

ARTEMIS is a new review tool of the IAEA, so this will be the first ARTEMIS mission in the Federal Republic of Germany.

L Annexes

(a) List of spent fuel management facilities

The following tables list the facilities for spent fuel management:

- Wet storage facilities for spent fuel and their inventories, as at: 31 December 2016 (Table L-1),
- Central storage facilities for spent fuel assemblies and heat-generating radioactive waste and Jülich cask storage facility, as at 31 December 2016 (Table L-2),
- Pilot conditioning plant (PKA) Gorleben (Table L-3),
- Main characteristics of the spent fuel storage facilities licensed or applied for under § 6 AtG, as at 31 December 2016 (Table L-4).

Table L-1: Wet storage facilities for spent fuel and their inventories, as at: 31 December 2016

Nuclear Power Plant	Licensed positions	Number of positions available for storage[1)]	of which not yet occupied	Stored quantity[2)] [Mg HM]
Brunsbüttel	817	490	370	21
Krümmel	1,690	1,445	855	101
Brokdorf	768	493	54	238
Unterweser	615	519	315	110
Grohnde	768	550	144	221
Emsland	768	569	117	243
Biblis Block A	582	575	575	0
Biblis Block B	578	574	68	271
Obrigheim[3)]	980	980	638	100
Philippsburg 1	948	948	948	0
Philippsburg 2	780	575	58	280
Neckarwestheim I[4)]	310+83	310+83	141+4 (145)	62+28 (90)
Neckarwestheim II	786	508	51	246
Gundremmingen B	3,219	2,414	110	401
Gundremmingen C	3,219	2,414	280	371
Isar 1	2,232	1,939	205	302
Isar 2	792	547	101	239
Grafenrheinfeld	715	695	98	321

1) taking into account positions that must be kept free for unloading of the core and other positions that cannot be used
2) spent and partially spent fuel assemblies
3) extension outside the reactor building
4) in addition to the capacity of the pool in unit 1 there are 83 positions usable in unit 2, 79 of which occupied, 4 vacant

Table L-2: Central storage facilities for spent fuel assemblies and heat-generating radioactive waste and Jülich cask storage facility, as at 31 December 2016

Site	Types of containers	Licensed quantities	already stored
Ahaus	CASTOR® V/19, V/19, Series 06 onwards and V/52 at a total of 370 storage positions CASTOR® THTR/AVR at a total of 50 storage positions (equals 320 container positions) CASTOR® MTR 2	3,960 Mg HM $2x10^{20}$ Bq	3 CASTOR® V/52 (26 Mg HM) 3 CASTOR® V/19 (29 Mg HM) (6 storage positions) 305 CASTOR® THTR/AVR (48 storage positions) 18 CASTOR® MTR 2 (7 storage positions)
Gorleben	CASTOR® Ia, Ib, Ic, IIa, V/19, V/52, TN 900/1-21 and CASTOR® HAW 20/28 CG, up to Series no. 15, CASTOR® HAW 20/28 CG from Series no. 16, TS 28V and TN 85, TS 28V and CASTOR® HAW 28M at a total of 420 storage positions	3,800 Mg HM $2x10^{20}$ Bq	1 CASTOR® IIa (5 Mg HM) 1 CASTOR® Ic (3 Mg HM) 3 CASTOR® V/19 (29 Mg HM) 74 CASTOR® HAW 20/28 CG with 2,072 glass canisters 12 TN 85 with 336 glass canisters 1 TS 28 V with 28 glass canisters 21 CASTOR® HAW 28M with 588 glass canisters
Rubenow	CASTOR® 440/84, CASTOR® KRB-MOX, CASTOR® HAW 20/28 CG and CASTOR® KNK at 80 storage positions	585 Mg HM $7.5x10^{18}$ Bq	6 CASTOR® 440/84 from Rheinsberg (48 Mg HM) 56 CASTOR® 440/84 and 3 CASTOR® KRB-MOX from Greifswald (535 Mg HM) 4 CASTOR® KNK with fuel rods from Karlsruhe and the research vessel „Otto Hahn“ 5 CASTOR® HAW 20/28 CG SN 16 with 140 glass canisters from VEK
Jülich	CASTOR® THTR/AVR (max. 158 containers)	225 kg nuclear fuel; $1.29x10^{17}$ Bq	approx. 290,000 AVR fuel element spheres in 152 CASTOR® THTR/AVR

Table L-3: Pilot conditioning plant (PKA) Gorleben

Site	Purpose	Capacity	Status
Gorleben	Design: Conditioning of spent fuel assemblies from power and research reactors; reloading of HLW glass canisters into packages suitable for disposal According to stipulation of 11 June 2001: Use restricted to the repair of defect containers	35 Mg HM/a (conditioning)	Constructed, but not in operation. Licensed by 3rd Partial Construction License (TEG) of 18/19 December 2000. Immediate execution has not been applied for.

Table L-4: Main characteristics of the spent fuel storage facilities licensed or applied for under § 6 AtG, as at 31 December 2016

Nuclear power plant *Land*	Applicant Date of application	Mass HM [Mg]	Activity [Bq]	Thermal power [MW]	Storage positions	Type Dimensions (L x W x H) wall/roof [m]	Container	Mass being stored (containers)
NPP Biblis (KWB) Hesse	RWE Power AG and RWE Rheinbraun AG 23. December 1999	1,400	$8.5 \cdot 10^{19}$	5.3	135	WTI concept 92x38x18 0.85/0.55	CASTOR® V/19	723 Mg HM (74+1 containers)
NPP Brokdorf (KBR) Schleswig-Holstein	Kernkraftwerk Brokdorf GmbH & Co. oHG and E.ON Kernkraft GmbH[1)] 20. December 1999	1,000	$5.5 \cdot 10^{19}$	3.75	100	STEAG concept 93x27x23 1.20/1.30	CASTOR® V/19	281 Mg HM (29 containers)
NPP Brunsbüttel (KKB)[2)] Schleswig-Holstein	Kernkraftwerk Brunsbüttel GmbH 30. November 1999	450	$6 \cdot 10^{19}$	2.0	80	STEAG concept 83x27x23 1.20/1.30	CASTOR® V/52	89 Mg HM (11 containers)
NPP Grafenrheinfeld (KKG) Bavaria	E.ON Kernkraft GmbH[1)] 23. February 2000	800	$5 \cdot 10^{19}$	3.5	88	WTI concept 62x38x18 0.85/0.55	CASTOR® V/19	204 Mg HM (21 containers)
NPP Grohnde (KWG) Lower Saxony	Gemeinschaftskernkraftwerk Grohnde GmbH & Co. oHG, Gemeinschaftskraftwerk Weser GmbH and E.ON Kernkraft GmbH[1)] 20. December 1999	1,000	$5.5 \cdot 10^{19}$	3.75	100	STEAG concept 93x27x23 1.20/1.30	CASTOR® V/19	293 Mg HM (30 containers)

Nuclear power plant *Land*	Applicant Date of application	Mass HM [Mg]	Activity [Bq]	Thermal power [MW]	Storage positions	Type Dimensions (L x W x H) wall/roof [m]	Container	Mass being stored (containers)
NPP Gundremmingen (KRB) Bavaria	RWE Power AG, E.ON Kernkraft GmbH and Kernkraftwerk Gundremmingen GmbH 25. February 2000	1,850	$2.4 \cdot 10^{20}$	6.0	192	WTI concept 104x38x18 0.85/0.55	CASTOR® V/52	413 Mg HM (48 containers)
NPP Isar (KKI) Bavaria	E.ON Kernkraft GmbH[1)] and E.ON Bayern AG 23. February 2000	1,500	$1.5 \cdot 10^{20}$	6.0	152	WTI concept 92x38x18 0.85/0.55	CASTOR® V/52 CASTOR® V/19 TN 24 E	338 Mg HM (36 containers)
NPP Krümmel (KKK) Schleswig-Holstein	Kernkraftwerk Krümmel GmbH & Co.oHG 30. November 1999	775	$0.96 \cdot 10^{20}$	3.0	80	STEAG concept 88x27x23 1.20/1.30	CASTOR® V/52	252 Mg HM (29 containers)
NPP Emsland (KKE) Lower Saxony	Stadt Lingen and Kernkraftwerke Lippe-Ems GmbH 22. December 1998	1,250	$6.9 \cdot 10^{19}$	4.7	130	STEAG concept 110x30x20 1.20/1.30	CASTOR® V/19	368 Mg HM (38 containers)
NPP Neckarwestheim (GKN) Baden-Wuerttemberg	Gemein-schaftskernkraft-werk Neckar GmbH 20. December 1999	1,600	$8.3 \cdot 10^{19}$	3.5	151	2 tunnel tubes 112 bzw. 82 x 12.8 x 17.3	CASTOR® V/19 TN 24 E	456 Mg HM (53 containers)
NPP Philippsburg (KKP) Baden-Wuerttemberg	EnBW Kraftwerke AG 20. December 1999	1,600	$1.5 \cdot 10^{20}$	6.0	152	WTI concept 92x37x18 0.70/0.55	CASTOR® V/19 CASTOR® V/52	522 Mg HM (58 containers)
NPP Unterweser (KKU) Lower Saxony	E.ON Kernkraft GmbH[1)] 20. December 1999	800	$4.4 \cdot 10^{19}$	3.0	80	STEAG concept 80x27x23 1.20/1.30	CASTOR® V/19	262 Mg HM (27 containers)

Nuclear power plant ***Land***	**Applicant Date of application**	**Mass HM [Mg]**	**Activity [Bq]**	**Thermal power [MW]**	**Stor-age posi-tions**	**Type Dimensions (L x W x H) wall/roof [m]**	**Container**	**Mass being stored (containers)**
NPP Obrigheim (KWO) Baden-Wuerttemberg[3)]	Kernkraftwerk Obrigheim GmbH 22. April 2005	100	$4.4 \cdot 10^{18}$	0.3	15	Special hybrid solution 35x18x17 0.85/0.55	CASTOR® 440 mvK	- (License not yet granted)

[1)] Now PreussenElektra GmbH

[2)] With the decision of the Federal Administrative Court of 16 January 2015 to reject the complaints of the Federal Office for Radiation Protection (BfS) against the non-admission of appeal in the court proceedings concerning the on-site storage facility at Brunsbüttel, the judgement of the Schleswig-Holstein Higher Administrative Court revoking the storage licence according to § 6 AtG has become final. On 16 November 2015, the operator applied for a new licence for the storage of nuclear fuel in the existing storage facility at the Brunsbüttel NPP according to § 6 AtG. The new application comprises the storage of all nuclear fuel already stored at the site with the following limits: mass of spent fuel 200 Mg HM, thermal power 300 kW, activity $4.4 \cdot 10^{18}$ Bq.

[3)] It is foreseen to move the fuel elements currently being stored at the Obrigheim site to the on-site storage facility at Neckarwestheim.

(b) List of radioactive waste management facilities

The following tables list the radioactive waste management facilities:

- Examples of stationary facilities for the conditioning of radioactive waste for own needs and third parties (Table L-5),
- Examples of mobile facilities for the conditioning of radioactive waste (Table L-6),
- Storage facilities for radioactive waste – Central storage facilities (Table L-7),
- Storage facilities for radioactive waste – Operational buffer storage facilities in nuclear power plants (in operation or permanently shut-down) (Table L-8),
- Storage facilities for radioactive waste – operational buffer storage facilities in nuclear power plants (under decommissioning) (Table L-9),
- Storage facilities for radioactive waste – storage facilities in research institutions (Table L-10),
- Storage facilities for radioactive waste – storage facilities of the nuclear and other industries (Table L-11),
- Storage facilities for radioactive waste – *Land* collecting facilities (for waste from research institutions see Table L-10) (Table L-12),
- Repositories and other storage facilities for radioactive waste (Table L-13).

Table L-5: Examples of stationary facilities for the conditioning of radioactive waste for own needs and third parties

Operator	Installation site	Installation name	Installation description
GNS Gesellschaft für Nuklear-Service mbH	Jülich	PETRA drying installation	Drying of waste in 200-l drums, 280-l drums or 400-l drums
		FAKIR high-pressure hydraulic press	High-pressure compaction of waste to pellets with the aid of metal cartridges or 200-l drums, waste volume reduction by up to factor 10
Eckert & Ziegler Nuclitec GmbH	Braunschweig	Drying installation	Drying of drums up to the specified residual humidity
		Compacting installation	Compaction of 200-l drums and scrunch drums, pressing power ≥ 30 MPa Capacity: 5,000 – 10,000 pressing sequences/a
		Decontamination cell	Decontamination of equipment parts (e.g. sandblasting); crushing of equipment parts (e.g. cutting, sawing), max. weight 1 Mg/piece
		Cementing installation	Immobilisation of waste water with fixing materials, immobilisation of ion-exchange resins with fixing materials
		Shredding installation	Crushing of waste, segregation of solid and liquid constituents, homogenisation, sampling
EWN Entsorgungswerk für Nuklearanlagen GmbH, formerly Energiewerke Nord GmbH	Rubenow (Greifswald)	FAKIR high-pressure hydraulic press	High-pressure compaction of radioactive waste in 180-l press drums and 200-l drums as well as loose waste with the aid of metal cartridges
		PETRA drying installation and drying chamber	Drying of solid and liquid radioactive waste in 200-l drums, 280-l drums, 400-l drums or 580-l drums
		Hydraulic shears	Cutting up of metals (scrap shear MARS with pre-compaction)
		Dismantling rooms	Dismantling of metals by use of thermal processes, e.g. autogenous cutting and plasma cutting
		Evaporation facilities	Processing of radioactive liquid waste; throughput up to 3 m³/h
		In-drum drying installation	Processing of evaporator concentrates; processing of up to eight 200-l drums simultaneously
		Chamber filtration installation	Separation of solids from radioactive liquids

Operator	Installation site	Installation name	Installation description
Kerntechnische Entsorgung Karlsruhe GmbH – KTE Business unit: Hauptabteilung Dekontaminationsbetriebe (HDB) (formerly Wiederaufarbeitungsanlage Karlsruhe GmbH, WAK)	Karlsruhe	Compacting installation (ILW scrapping)	Compaction of radioactive waste with negligible heat generation with high dose rate; remote handling techniques with lock and working cells, manipulators, hydraulic shears, hydraulic press
		Compacting installation (LLW scrapping)	Compaction of radioactive waste with negligible heat generation with low dose rate; caisson technique with gas protection suits; compaction with pre- and high-efficiency compactor; max. throughput: 3,000 m³/a; volume reduction factor: 6
		Combustion installation	Combustion of solid and liquid waste contaminated by alpha and beta nuclides; max. throughput: 165 Mg/a; volume reduction factor (with subsequent high-pressure compaction of the ash): approx. 100
		Old evaporation and immobilisation installation (evaporation of LLW no. I)	Evaporation of low level radioactive waste water with subsequent cementation of the residues; max. throughput: 6,000 m³/a; decommissioning since 2012
		New evaporation installation for LLW	Evaporation of low level radioactive waste water; max. throughput: 600 m³/a; volume reduction factor: up to approx. 20
		Cementing installation	Cementation of residues from the “New evaporation installation for LLW”
		Equipment decontamination	Disassembling, conditioning and decontamination of solid, non-combustible residues; throughput: up to approx. 1,200 Mg/a
		Fluidised bed drying installation	Drying of scrubber waters from the combustion installation
		Various drying facilities	Drying of solid radioactive LLW; actual capacity: 38 drums; future capacity: 66 drums; drying of radioactive ILW; capacity: 2 drums/MOSAIK
Jülicher Entsorgungsgesell tsorgungsgesellschaft für Nuklearanlagen mbH (JEN) (formerly Forschungszentrum Jülich GmbH (FZJ))	Jülich	Dismantling/decontamination cabin REBEKA	Decontamination in two steel cabins of parts weighing up to 25 Mg by mechanical means with subsequent dismantling
		Fluidised bed granulation drying installation	Drying installation for radioactive waste water concentrates
		HPA drying installation	Drying of liquid and moist waste
		Drying installation of the PETRA type	Drum drying
		Evaporation installation	Processing of low active waste water, concentrates and sludges; total volume: 825 m³, delivery in tankers
		Combustion installation JÜV	Processing of low active liquids and solids; annual throughput: up to 240 Mg of solids and 40 Mg of liquids

Operator	Installation site	Installation name	Installation description
Helmholtz-Zentrum Berlin GmbH	Berlin	Evaporator	Circulation evaporator
		Cementation	Cementation of evaporator concentrates and other aqueous waste from storage tanks
Strahlenschutz, Analytik und Entsorgung Rossendorf e. V. (VKTA)	Rossendorf	Dismantling installations	Plasma cutting installation up to 20 mm; cold and band-saws up to 350 mm Ø; hydraulic shear
		In-drum press	30-l to 40-l bags are pressed directly into waste drums.
		Drying installation for drums	2-drum drying installation for the drying of sludges, ion-exchange resins, humid soil; drying time: 10-14 days; volume reduction: max. 60 %
		Resin drying installation	Drying of max. 240 l of spent ion-exchange resin; volume reduction: approx. 50 %
		Dismantling box for aerosol filters	In the dismantling box, aerosol filters are dismantled until the parts can be placed in a docked 200-l drum.
		Ion exchange installation	Treatment of radioactive waste water; plant throughput: 2 m³/h
		High-pressure blast installation	Decontamination of components by means of blasting in a box; manageable dimensions of the components 600 mm x 600 mm x 200 mm; mass up to 20 kg
		Ultrasonic cleaning installation	Decontamination of components up to a size of 800 mm x 500 mm x 200 mm with a maximum mass of 20 kg
Siemens AG	Karlstein	Cementation	Filling of Konrad containers with construction rubble and cementation of Konrad containers; cementation of waste in drums
Siempelkamp Nukleartechnik GmbH	Krefeld	CARLA installation	Melting of contaminated metallic residues
URENCO Deutschland GmbH	Gronau	Solidification installation for concentrates	Cementation

Table L-6: Examples of mobile facilities for the conditioning of radioactive waste

Operator	Installation name	Installation description	License
GNS Gesellschaft für Nuklear-Service mbH	High-pressure hydraulic press FAKIR	Processing of waste to pellets with the aid of metal cartridges	Nationwide valid exclusive licence for all nuclear installations according to §§ 7, 9, 9a AtG and § 7 StrlSchV
	Drying installation of the FAVORIT type	Decanting and drying installation for liquid radioactive waste (evaporator concentrates, decontamination solutions, resins) as well as drying of solid waste pursuant to the principle of vacuum drying	Nationwide valid exclusive licence for all nuclear installations according to §§ 7, 9, 9a AtG and § 7 StrlSchV
	Drying installation of the PETRA type	Drying installation for humid radioactive waste being packaged in 200-, 280- and 400-l drums pursuant to the principle of vacuum drying	Nationwide valid exclusive licence for all nuclear installations according to §§ 7, 9, 9a AtG and § 7 StrlSchV
	Drying installation of the KETRA type	Drying installation for humid solid radioactive waste (e.g. core scrap) being packaged in MOSAIK® containers	Nationwide valid exclusive licence for all nuclear installations according to §§ 7, 9, 9a AtG and § 7 StrlSchV
	Decanting installation of the FAFNIR type	Decanting installation for radioactive resins (e.g. powder and bead resins) pursuant to the principle of vacuum drying	Nationwide valid exclusive licence for all nuclear installations according to §§ 7, 9, 9a AtG and § 7 StrlSchV
	Mobile exhaust installation for powder resins of the PUSA type	Decanting installation for dry fluid powder resins (e.g. ion-exchange resins from BWR) pursuant to the principle of vacuum suction	Nationwide valid exclusive licence for all nuclear installations according to §§ 7, 9, 9a AtG and § 7 StrlSchV
	Final dewatering installation of the NEWA type	Final dewatering of decanted radioactive resins (e.g. powder and bead resins)	Nationwide valid exclusive licence for all nuclear installations according to §§ 7, 9, 9a AtG and § 7 StrlSchV
	Disassembling and packaging installation of the ZVA type	Underwater disassembly of core scrap with subsequent high-pressure compaction in insert baskets	Nationwide valid exclusive licence for all nuclear installations according to §§ 7, 9, 9a AtG and § 7 StrlSchV
	Underwater shear of the UWS type	Underwater disassembly of core scrap	Nationwide valid exclusive licence for all nuclear installations according to §§ 7, 9, 9a AtG and § 7 StrlSchV

Table L-7: Storage facilities for radioactive waste – Central storage facilities

Name of facility and site	Purpose of the facility	Capacity acc. to licence	Licence	Remarks
Gorleben waste storage facility (drum storage facility), Lower Saxony	Storage of radioactive waste from NPP, medicine, research and trade	200-l, 400-l drums, type III concrete containers, type I-II cast-iron containers, type I-IV containers with a total activity of up to 5×10^{18} Bq	Handling licences according to § 3 StrlSchV*) of 27 October 1983, 13 October 1987 and 13 September 1995	In operation since October 1984
Ahaus waste storage facility, North Rhine-Westphalia	Storage of radioactive waste from NPP	Konrad containers, 20' containers and facility components; total activity for storage area no. I limited to 1.0×10^{17} Bq	Handling licences according to § 7 StrlSchV of 9 November 2009	In operation since July 2010
Unterweser waste storage facility, Lower Saxony	Storage of low level radioactive waste from the nuclear power plants Unterweser and Stade	200-l and 400-l drums, concrete containers, sheet steel containers, cast-iron containers with a total activity of up to 1.85×10^{15} Bq	Handling licences according to § 3 StrlSchV*) of 24 June 1981, 29 November 1991 and 6 November 1998	In operation since autumn 1981
Storage facility of the EVU, Mitterteich, Bavaria	Storage of waste with negligible heat generation from Bavarian nuclear facilities	40,000 waste packages (200-l, 400-l drums or cast-iron containers)	Handling licences according to § 3 StrlSchV*) of 7 July 1982	In operation since July 1987
Zwischenlager Nord (ZLN), Rubenow/Greifswald Mecklenburg-West Pomerania	Storage of operational and decommissioning waste from the NPPs Greifswald and Rheinsberg, including storage of dismantled large components; storage of residues and waste that will be conditioned for third party	165,000 m³	Handling licences according to § 3 StrlSchV*) of 20 February 1998	In operation since March 1998
Hauptabteilung Dekontaminationsbe-triebe (HDB), Karlsruhe Baden-Wuerttemberg	Storage of waste with negligible heat generation from FZK, KTE, ITU, *Land* collecting facility Baden-Wuerttemberg and, in a limited way or for buffering purposes, from third parties	Handling (conditioning and storage) of radioactive residues und waste with contents of fissile material up to a total activity of 4.5×10^{17} Bq	Handling licence according to § 9 AtG of 25 November 1983, superseded by licence according to § 9 AtG of 29 June 2009	In operation since December 1964

*) as amended on 13 October 1976 or 30 June 1989 respectively

Table L-8: Storage facilities for radioactive waste – Operational buffer storage facilities in nuclear power plants (in operation or permanently shut-down)

Name of facility and site	Purpose of the facility	Capacity acc. to licence	Licence	Remarks
NPP Biblis Units A and B	Storage of radioactive waste from the operation of the NPP	7,500 packages	§ 7 AtG, § 7 StrlSchV	Licence according to § 7 StrlSchV for the storage of radioactive operational waste (3,000 m^3) at the on-site storage facility, hall 2
NPP Brokdorf	Storage of radioactive waste from the operation of the NPP	560 m^3	§ 7 AtG	-
NPP Brunsbüttel	Storage of radioactive waste from the operation of the NPP	3,225 m^3 / 4,150 m^3	§ 7 StrlSchV	Hall I and II for keeping the waste ready for transport
NPP Emsland	Storage of radioactive waste from the operation of the NPP	185 m^3	§ 7 AtG	-
NPP Grafenrheinfeld	Storage of radioactive waste from the operation of the NPP	Raw waste: 200 m^3 Conditioned waste: 200 m^3	§ 7 AtG	-
NPP Grohnde	Storage of radioactive waste from the operation of the NPP	280 m^3	§ 7 AtG	-
NPP Gundremmingen Units B and C	Storage of radioactive waste from the operation of the NPP	300 m^3 conditioned waste 1,305 m^3 liquid waste	§ 7 AtG	-
NPP Isar 1	Storage of radioactive waste from the operation of the NPP	4,000 m^3	§ 7 AtG	-
NPP Isar 2	Storage of radioactive waste from the operation of the NPP	160 m^3	§ 7 AtG	-
NPP Krümmel	Storage of radioactive waste from the operation of the NPP	1,340 m^3	§ 7 AtG	-
NPP Neckarwestheim Units 1 and 2	Storage of radioactive waste from the operation of the NPP	3,264 m^3	§ 7 AtG	-
NPP Philippsburg Units 1 and 2	Storage of radioactive waste from the operation of the NPP	3,775 m^3	§ 7 AtG	-
NPP Unterweser	Storage of radioactive waste from the operation of the NPP	350 m^3	§ 7 AtG	-

Table L-9: Storage facilities for radioactive waste – operational buffer storage facilities in nuclear power plants (under decommissioning)

Name of facility and site	Purpose of the facility	Capacity acc. to licence	Licence	Remarks
NPP Greifswald Units 1 - 5	Storage of radioactive waste and residues from the decommissioning of the NPP, the KKR and third parties	140 20' Container	§ 7 AtG	Storage space for the collection and storage of radioactive waste/residues
NPP Gundremmingen Unit A	Storage of radioactive waste from the decommissioning of the NPP	1,678 m^3 conditioned waste 318 m^3 liquid waste	§ 7 AtG	Conditioned waste
THTR Hamm-Uentrop	Storage of radioactive waste from the operation and decommissioning of the NPP	1,160 m^3	§ 7 AtG	-
AVR Jülich	Storage of radioactive waste from the decommissioning of the NPP	235 m^3	§ 7 AtG	-
NPP Lingen	Storage of radioactive waste from the operation and decommissioning of the NPP	170 m^3	§ 7 AtG	-
NPP Mülheim-Kärlich	Storage of radioactive waste from the operation of the NPP	43 m^3	§ 7 AtG	-
NPP Obrigheim	Storage of radioactive waste from the operation and the post-operational phase of the NPP	3,300 m^3	§ 7 AtG	-
NPP Rheinsberg	Storage of radioactive waste from the decommissioning of the NPP		§ 7 AtG	Only buffer storage
NPP Stade	Storage of radioactive waste from the operation and the post-operational phase of the NPP	100 m^3	§ 7 AtG	-
NPP Stade	Storage of radioactive waste from the decommissioning of the NPP	4,000 m^3	§ 7 StrlSchV	Commissioning: 1 August 2007
NPP Würgassen	Storage of radioactive waste from the decommissioning of the NPP	4,600 m^3	§ 7 AtG	-

Table L-10: Storage facilities for radioactive waste – storage facilities in research institutions

Name of facility and site	Kind of waste stored	Capacity acc. to licence	Licence	Remarks
Forschungs- und Messreaktor Braunschweig (FMRB)	Operational waste from FMRB	Decommissioning waste from FMRB (174 m^3)	§ 7 AtG	Buffering of waste
Research reactor Garching	Operational waste from the research reactor	FRM: 100 m^3 FRM2: 68 m^3	§ 7 AtG	There is no waste storage facility with an independent handling or operating licence available at the Garching site. There are capabilities to allocate radioactive waste for transport.
Research centre Geesthacht	Operational waste from the research reactor	145 m^2, 112 m^2, 226 m^2	§ 3 StrlSchV*), § 7 StrlSchV	Storage space for conditioned waste
JEN mbH	Radioactive waste with negligible heat generation, and AVR fuel spheres, activated bulky waste	11,470 drums and 780 Konrad containers Licence for storage of AVR fuel elements	§ 3 StrlSchV*) §§ 6, 9 AtG	-
VKTA Rossendorf	Operational and decommissioning waste from the research institution	2,270 m^3 (total gross storage volume)	§ 3 StrlSchV*)	Storage facility Rossendorf (ZLR)

*) as amended on 13 October 1976 and 30 June 1989, respectively

Table L-11: Storage facilities for radioactive waste – storage facilities of the nuclear and other industries

Name of facility and site	Kind of waste stored	Capacity acc. to licence	Licence	Remarks
Nuclear industry				
Advanced Nuclear Fuels GmbH (ANF), Lingen	Operational waste from fuel assembly fabrication	950 200-l drums	§ 7 AtG	-
Siemens, Karlstein	Waste from dismantling and operation	5,300 m³ (2,100 m^3 according to § 9 AtG, 3,200 m^3 according to § 3 StrlSchV*))	§ 9 AtG, § 3 StrlSchV*)	-
Storage facility of DAHER NUCLEAR TECHNOLOGIES (formerly NCS), Hanau	Conditioned waste with negligible heat generation, operational waste and waste from dismantling originating from 1.: Siemens 2.: NUKEM, AREVA NP, GNS et al.	1.: 1,250 Konrad containers 2.: 800 m^2	§ 7 StrlSchV § 3 StrlSchV*)	-
Urenco, Gronau	Operational waste from uranium enrichment	Storage facility: 220 m²; up to 48 Konrad Type V containers; buffer storage facility 1: 150 200-l drums; buffer storage facility 2: 230 m², 84 200-l drums (double-stacked); 96 storage positions for “lost concrete shielding” (single-stacked)	§ 7 AtG	Nuclear commissioning according to licence 7/6 UAG of buffer storage facility 2 started on 7 July 2016.
Other industry				
Eckert & Ziegler Nuclitec GmbH, Leese	Waste from the medical field, research and industry	13,620 200-l drums	§ 7 StrlSchV	-

*) as amended on 13 October 1976 and 30 June 1989, respectively

Table L-12: Storage facilities for radioactive waste – *Land* collecting facilities (for waste from research institutions see Table L-10)

Name of facility and site	Kind of waste stored	Capacity acc. to licence	Licence	Remarks
Land collecting facility Baden-Wuerttemberg, Karlsruhe	Waste from the medical field, research and industry	No capacity limit stated (capacity HDB: 78,664 m³)	§ 9 AtG	*Land* collecting facility in HDB, operator HDB
Land collecting facility Bavaria, Mitterteich	Waste from the medical field, research and industry	10,000 packages	§ 3 StrlSchV*)	Approx. 2,900 m³ available
Land collecting facility Berlin, Berlin	Waste from the medical field, research and industry	800 m³	§ 3 StrlSchV*)	At the Helmholtz-Zentrum Berlin
Land collecting facility Hesse, Ebsdorfergrund	Waste from the medical field, research and industry	400 m³	§ 6 AtG § 3 StrlSchV*)	-
Land collecting facility Mecklenburg-Western Pomerania, Rubenow/Greifswald	Waste from the medical field, research and industry	20‘ containers	§ 3 StrlSchV*)	*Land* collecting facility at ZLN, joint use by Brandenburg
Land collecting facility North Rhine-Westphalia, Jülich	Waste from the medical field, research and industry	9,000 200-l drums	§ 3 StrlSchV*), § 9 AtG	On the site of the Forschungszentrum Jülich GmbH (FZJ)
Land collecting facility Rhineland-Palatinate, Ellweiler	Waste from the medical field, research and industry	α+β/γ activity limited to: 1.6×10^{13} Bq	§ 9 AtG, § 3 StrlSchV*)	Approx. 600 m³ available
Land collecting facility Saarland, Elm-Derlen	Waste from the medical field, research and industry	50 m³	§ 3 StrlSchV*)	-
Land collecting facility Saxony, Rossendorf/Dresden	Waste from the medical field, research and industry	300 m³	§ 3 StrlSchV*)	At VKTA, also used by Thuringia and Saxony-Anhalt
Land collecting facility of the four north German coastal Federal States, Geesthacht	Waste from the medical field, research and industry	68 m² storage area	§ 3 StrlSchV*)	Shared use by Schleswig-Holstein, Hamburg and Bremen, the Lower Saxon contingent has been exhausted for several years already.

Name of facility and site	Kind of waste stored	Capacity acc. to licence	Licence	Remarks
Land collecting facility Lower Saxony, Leese	Waste from the medical field, research and industry	Hired storage capacity: 1,485 drums, 3,400 drums, max. 50 Konrad containers	§ 7 StrlSchV	Since 2002, the *Land* collecting facility Lower Saxony has been operated by the GNS Gesellschaft für Nuklear-Service (GNS). The acceptance of raw waste for the *Land* collecting facility Lower Saxony and their conditioning is performed by GNS at its facilities on the premises of the Forschungszentrum Jülich GmbH (FZJ). After their conditioning and packaging in a manner that is suitable for disposal, the waste is transported to the storage facility of the company Eckert & Ziegler Nuclitec at Leese. At that storage facility, also 4,885 200-l drums are stored which were received from the *Land* collecting facility Lower Saxony before 2002. In addition, waste of the *Land* collecting facility Lower Saxony is stored at the Helmholtz-Zentrum für Material- und Küstenforschung GmbH at Geesthacht together with waste from the *Land* collecting facilities of Bremen, Hamburg and Schleswig-Holstein.
Central collecting point of the German Federal Armed Forces, Munster	Waste originating from activities of the German Federal Armed Forces	1,600 m³	§ 3 StrlSchV*)	-

*) as amended on 13 October 1976 or 30 June 1989 respectively

Table L-13: Repositories and other storage facilities for radioactive waste

Name of facility and site	Purpose of the facility	Capacity acc. to licence	Licence	Remarks
Asse II mine Remlingen, Lower Saxony	Disposal of low and intermediate level radioactive waste in the context of research and development work for the disposal of radioactive and radiotoxic waste	Between 1967 and 1978 approx. 124,500 LLW waste packages, including approx. 15,000 so-called “Lost concrete shieldings” (VBA) with higher level waste and approx. 1,300 ILW waste packages were emplaced for trial purposes. Total activity of the waste emplaced: 2.3×10^{15} Bq (as per 1 January 2010)	Licence according to § 3 StrlSchV as amended on 15 October 1965 Handling licence according to § 7 StrlSchV and acquisition of facts according to § 9 AtG	Geological host formation: rock salt Retrieval of the waste in process of planning
Konrad repository Salzgitter, Lower Saxony	Repository for radioactive waste with negligible heat generation		Licence according to § 9b AtG, approval of the plan was granted on 22 May 2002, decision is final since 26 March 2007	Geological host formation: coral oolite (iron ore) beneath a water-impermeable barrier from the cretaceous period Refitting underway since 2007
Morsleben repository for radioactive waste (ERAM) Saxony-Anhalt	Disposal of low and intermediate level waste with mainly short-lived radionuclides	Disposal of 36,753 m^3 low and intermediate level waste in total, total activity of all radioactive waste emplaced in the order of magnitude of 10^{14} Bq, activity of alpha-sources in the order of magnitude of 10^{11} Bq.	22 April 1986: Permanent operating licence granted. 12 April 2001: A statement is made to the effect that no further radioactive waste will be accepted for disposal	Geological host formation: rock salt On 28 September 1998 emplacement operations were discontinued. Closure has been applied for.

(c) List of nuclear facilities being out of operation

The following tables list those nuclear facilities which are currently out of operation, divided into the following categories:

- Nuclear power plants in the process of decommissioning as at 30. April 2017 (Table L-14),
- Research reactors with an electric power of more than 1 MW permanently shut down, in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at 30 April 2017 (Table L-15),
- Research reactors with an electric power of less than 1 MW permanently shut down (Table L-16),
- Experimental and demonstration reactors in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at 30 April 2017 (Table L-17),
- Commercial fuel cycle facilities in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at 30 April 2017 (Table L-18),
- Research, experimental and demonstration facilities of the nuclear fuel cycle, decommissioning completed and facilities released from nuclear regulatory control, as at 30 April 2017 (Table L-19),
- Nuclear power plants that were shut down and are now in the post-operational phase, as at 30 April 2017 (Table L-20).

Table L-14: Nuclear power plants in the process of decommissioning as at 30. April 2017

	Name of facility, location	Operator	Type of facility, electrical output (gross)	First critica-lity	Final shut-down	Status	Planned final status
1	KKR Rheinsberg, Brandenburg	EWN GmbH	PWR (VVER) 70 MWe	03/1966	06/1990	Dismantling	Removal
2	KRB A Gundremmingen, Bavaria	Kernkraftwerk Gundremmingen GmbH	BWR 250 MWe	08/1966	01/1977	Dismantling, alteration	Technology centre
3	KWL Lingen, Lower Saxony	Kernkraftwerk Lingen GmbH	BWR 252 MWe	01/1968	01/1977	Dismantling	Removal
4	KWO Obrigheim, Baden-Wuerttemberg	EnBW Kernkraft GmbH – Kernkraftwerk Obrigheim	PWR 357 MWe	09/1968	05/2005	Dismantling	Removal
5	KWW Würgassen, North Rhine-Westphalia	PreussenElektra GmbH	BWR 670 MWe	10/1971	08/1994	Dismantling	Removal
6	KKS Stade, Lower Saxony	PreussenElektra GmbH	PWR 672 MWe	01/1972	11/2003	Dismantling	Removal
7	KGR 1 Lubmin, Mecklenburg-Western Pomerania	EWN GmbH	PWR (VVER) 440 MWe	12/1973	12/1990	Dismantling	Partial dismantling, use as an industrial site
8	KWB-A Biblis, Hesse	REW Power	PWR 1,225 MWe	07/1974	08/2011	Dismantling	Removal
9	KGR 2 Lubmin, Mecklenburg-Western Pomerania	EWN GmbH	PWR (VVER) 440 MWe	12/1974	02/1990	Dismantling	Partial dismantling, use as an industrial site
10	KWB-B Biblis, Hesse	RWE Power	PWR 1,300 MWe	03/1976	08/2011	Dismantling	Removal
11	GKN I Neckarwestheim, Baden-Wuerttemberg	EnBW Kernkraft GmbH (EnKK)	PWR 840 MWe	05/1976	08/2011	Dismantling	Removal
12	KGR 3 Lubmin, Mecklenburg-Western Pomerania	EWN GmbH	PWR (VVER) 440 MWe	10/1977	02/1990	Dismantling	Partial dismantling, use as an industrial site
13	KKI 1 Essenbach, Bavaria	PreussenElektra	BWR 912 MWe	11/1977	08/2011	Dismantling	Removal

	Name of facility, location	Operator	Type of facility, electrical output (gross)	First critica-lity	Final shut-down	Status	Planned final status
14	KKP 1 Philippsburg, Baden-Wuerttemberg	EnBW Kernkraft GmbH (EnKK)	BWR 926 MWe	03/1979	08/2011	Dismantling	Removal
15	KGR 4 Lubmin, Mecklenburg-Western Pomerania	EWN GmbH	PWR (VVER) 440 MWe	07/1979	06/1990	Dismantling	Partial dismantling, use as an industrial site
16	KMK Mülheim-Kärlich, Rhineland-Palatinate	RWE Power AG	PWR 1,302 MWe	03/1986	09/1988	Dismantling	Reuse
17	KGR 5 Lubmin, Mecklenburg-Western Pomerania	EWN GmbH	PWR (VVER) 440 MWe	03/1989	11/1989	Dismantling	Partial dismantling, use as an industrial site

Table L-15: Research reactors with an electric power of more than 1 MW permanently shut down, in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at 30 April 2017

	Name of facility, location	Last operator	Type, thermal. output	First critica-lity	Final shut-down	Status	Planned final status
1	FMRB – Braunschweig, Lower Saxony	Physikalisch-Technische Bundesanstalt	Pool 1 MW	10/1967	12/1995	Released from the scope of the AtG except the storage facility	-
2	FR-2 – Karlsruhe, Baden-Wuerttemberg	KTE GmbH	Tank 44 MW	03/1961	12/1981	Reactor core in safe enclosure	Removal
3	FRG-1 – Geesthacht, Schleswig-Holstein	Helmholtz-Zentrum Geesthacht GmbH	Pool 5 MW	10/1958	06/2010	Shut down, fuel elements removed, decom-missioning applied for	Removal
4	FRG-2 – Geesthacht, Schleswig-Holstein	Helmholtz-Zentrum Geesthacht GmbH	Pool 15 MW	03/1963	05/1991	Shut down, partly dismantled	Removal
5	FRJ-1 MERLIN – Jülich, North Rhine-Westphalia	Forschungszentrum Jülich GmbH	Pool 10 MW	02/1962	03/1985	Removed	-
6	FRJ-2 DIDO – Jülich, North Rhine-Westphalia	JEN mbH (subsidiary of EWN)	DIDO 23 MW	11/1962	05/2006	Disman-tling	Removal
7	FRM – München, Bavaria	Technische Univer-sität München	Pool 4 MW	10/1957	07/2000	Disman-tling	Partial disman-tling, conver-sion into an auxiliary plant of FRM II
8	FRN – Neuherberg, Bavaria	Helmholtz Zentrum München GmbH	TRIGA 1 MW	08/1972	12/1982	Safe enclosure	Not yet decided
9	RFR – Rossendorf, Saxony	VKTA Rossendorf	Tank, WWR 10 MW	12/1957	06/1991	Disman-tling	Removal

Table L-16: Research reactors with an electric power of less than 1 MW permanently shut down, in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at 30 April 2017

	Name of facility, location	Operator	Type, thermal output	First criticality	Final shut-down	Status	Planned final status
1	ADIBKA – Jülich, North Rhine-Westphalia	Forschungszentrum Jülich GmbH	Homog. reactor 0.1 kW	03/1967	10/1972	Removed	-
2	AEG Nullenergie-Reaktor – Karlstein, Bavaria	Kraftwerk Union	Tank 0.1 kW	06/1967	01/1973	Removed	-
3	AKR-1 – Dresden, Saxony	Technische Universität Dresden	Homog. reactor 2 W	07/1978	03/2004	Converted and rededicated to AKR-2, operation since 07/2005	
4	ANEX – Geesthacht, Schleswig-Holstein	Helmholtz-Zentrum Geesthacht GmbH	Critical assembly, 0.1 kW	05/1964	02/1975	Removed	-
5	BER I – Berlin	Helmholtz-Zentrum Berlin GmbH	Homog. reactor 50 kW	07/1958	08/1972	Removed	-
6	FRF-1 – Frankfurt/M. (FRF-2 in the same building never reached criticality), Hesse	Johann-Wolfgang-Goethe-Universität Frankfurt/M.	Homog. reactor 50 kW	01/1958	03/1968	Removed	-
7	FRH – Hannover, Lower Saxony	Medizinische Hochschule Hannover	TRIGA 250 kW	01/1973	12/1996	Removed	-
8	HD I – Heidelberg, Baden-Wuerttemberg	Deutsches Krebsforschungszentrum Heidelberg	TRIGA 250 kW	08/1966	03/1977	Removed	-
9	HD II – Heidelberg, Baden-Wuerttemberg	Deutsches Krebsforschungszentrum Heidelberg	TRIGA 250 kW	02/1978	11/1999	Removed	-
10	KAHTER, Jülich, North Rhine-Westphalia	Forschungszentrum Jülich GmbH	Critical assembly 0.1 kW	07/1973	02/1984	Removed	-
11	KEITER, Jülich, North Rhine-Westphalia	Forschungszentrum Jülich GmbH	Critical assembly 1 W	06/1971	03/1982	Removed	-
12	PR-10, AEG Prüfreaktor, Karlstein, Bavaria	Kraftwerk Union	Argonaut 0.18 kW	01/1961	11/1975	Removed	-
13	RAKE, Rossendorf, Saxony	VKTA Rossendorf	Tank 0.01 kW	10/1969	11/1991	Removed	-
14	RRR, Rossendorf, Saxony	VKTA Rossendorf	Argonaut 1 kW	12/1962	09/1991	Removed	-

	Name of facility, location	Operator	Type, thermal output	First critica-lity	Final shut-down	Status	Planned final status
15	SAR, München, Bavaria	Technische Universität München	Argonaut 1 kW	06/1959	10/1968	Removed	-
16	SNEAK, Karlsruhe, Baden-Wuerttemberg	Karlsruher Institut für Technologie	Homog. reactor 1 kW	12/1966	11/1985	Removed	-
17	STARK, Karlsruhe, Baden-Wuerttemberg	Karlsruher Institut für Technologie	Argonaut 0.01 kW	01/1963	03/1976	Removed	-
18	SUR Aachen –North Rhine-Westphalia	RWTH Aachen	Homog. reactor < 1 W	09/1965	-	Decom-missioning applied for	Removal
19	SUR Berlin – Berlin	Technische Hochschule Berlin	Homog. reactor < 1 W	07/1963	10/2007	Removed	-
20	SUR Bremen – Bremen	Hochschule Bremen	Homog. reactor < 1 W	10/1967	06/1993	Removed	-
21	SUR Darmstadt – Hesse	Technische Hochschule Darmstadt	Homog. reactor < 1 W	09/1963	02/1985	Removed	-
22	SUR Hamburg – Hamburg	Fachhochschule Hamburg	Homog. reactor < 1 W	01/1965	08/1992	Removed	-
23	SUR Hannover –Lower Saxony	Universität Hannover	Homog. reactor < 1 W	12/1971	-	Decom-missioning applied for	Removal
24	SUR Karlsruhe –Baden-Wuerttemberg	Karlsruher Institut für Technologie	Homog. reactor < 1 W	03/1966	09/1996	Removed	-
25	SUR Kiel – Schleswig-Holstein	Fachhochschule Kiel	Homog. reactor < 1 W	03/1966	12/1997	Removed	-
26	SUR München –Bavaria	Technische Universität München	Homog. reactor < 1 W	02/1962	08/1981	Removed	-
27	SUAK – Karlsruhe, Baden-Wuerttemberg	Karlsruher Institut für Technologie	Fast sub-critical assembly < 1 W	11/1964	12/1978	Removed	-
28	SUA – München, Bavaria	Technische Universität München	Sub-critical assembly < 1 W	06/1959	10/1968	Removed	-
29	ZLFR – Zittau, Saxony	Hochschule Zittau/Görlitz	10 W	05/1979	03/2005	Removed	-

Table L-17: Experimental and demonstration reactors in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at 30 April 2017

	Name of facility, location	Operator	Type, thermal output (gross)	First critica-lity	Final shut-down	Status	Planned final status
1	AVR Atomversuch-skraftwerk, Jülich, North Rhine-Westphalia	JEN mbH	HTGR 15 MWe	08/1966	12/1988	Disman-tling	Removal
2	HDR Heißdampfreaktor, Großwelzheim, Bavaria	Karlsruher Institut für Technologie	SSR 25 MWe	10/1969	04/1971	Removed	-
3	KKN Niederaichbach Niederaichbach, Bavaria	Karlsruher Institut für Technologie	HWGCR 106 MWe	12/1972	07/1974	Removed	-
4	KNK II Kompakte Natriumgekühlte Reaktoranlage, Karlsruhe, Baden-Wuerttemberg	KTE	FBR 21 MWe	10/1977	08/1991	Disman-tling	Removal
5	MZFR Mehrzweck-forschungsreaktor, Karlsruhe, Baden-Wuerttemberg	KTE	PWR with D_2O 57 MWe	09/1965	05/1984	Disman-tling	Removal
6	Nuclear ship Otto Hahn, Geesthacht, Schleswig-Holstein	Helmholtz-Zentrum Geesthacht GmbH	PWR, vessel propulsion 38 MW	08/1968	02/1979	Nuclear ship released from AtG, RPV put into storage	Removal (RPV)
7	THTR-300 Thorium-Hochtemperaturreaktor, Hamm-Uentrop, North Rhine-Westphalia	Hochtemperatur-Kernkraft GmbH	HTGR 308 MWe	09/1983	09/1988	Safe enclosure	Not yet decided
8	VAK Versuch-satomkraftwerk, Kahl, Bavaria	Versuch-satomkraftwerk Kahl GmbH	BWR 16 MWe	11/1960	11/1985	Removed	-

Table L-18: Commercial fuel cycle facilities in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at 30 April 2017

	Name of facility, location	Operator	Start of operation	End of operation	Status	Planned final status
1	HOBEG fuel fabrication facility, Hanau, Hesse	Hobeg GmbH	1973	1988	Removed	-
2	NUKEM-A fuel fabrication facility, Hanau, Hesse	RD Hanau GmbH (formerly Nukem GmbH)	1962	1988	Removed	-
3	Siemens fuel fabrication facility, uranium unit, Hanau, Hesse	Siemens AG	1969	1995	Removed	-
4	Siemens fuel fabrication facility, MOX unit, Hanau, Hesse	Siemens AG	1968	1991	Removed	-
5	Siemens fuel fabrication facility, Karlstein unit (SBWK), Bavaria	Siemens AG	1966	1993	Continued conventional use	-
6	Karlsruhe reprocessing plant (WAK) including Karlsruhe vitrification plant (VEK), Baden-Wuerttemberg	KTE	1971	1990	Dismantling	Removal

Table L-19: Research, experimental and demonstration facilities of the nuclear fuel cycle, decommissioning completed and facilities released from nuclear regulatory control, as at 30 April 2017

	Name of facility, location	Operator	Start of operation	Final shutdown	Status	Planned final status
1	JUPITER Testanlage Wiederaufarbeitung – Jülich, North Rhine-Westphalia	Forschungszentrum Jülich GmbH	1978	1987	Removed	-
2	MILLI Laborextraktionsanlage – Karlsruhe, Baden-Wuerttemberg	Karlsruher Institut für Technologie	1970	1991	Removed	-
3	PUTE Plutoniumextraktionsanlage – Karlsruhe, Baden-Wuerttemberg	Karlsruher Institut für Technologie	1980	1991	Removed	-

Table L-20: Nuclear power plants that were shut down and are now in the post-operational phase, as at 30 April 2017

	Shutdown nuclear power plant, location	a) Operator b) Manufacturer c) Owner (shareholder)	Type, electrical output [MWe]	a) First criticality b) Expiration of permission for power generation c) Application for decommissioning
1	Brunsbüttel (KKB); Brunsbüttel Schleswig-Holstein	a) Kernkraftwerk Brunsbüttel b) AEG/KWU c) VENE 66,7%, PreussenElektra 33,3%	BWR; 806	a) 23.06.1976 b) 06.08.2011 c) 01.11.2012
2	Unterweser (KKU); Stadland Lower Saxony	a) PreussenElektra b) KWU c) PreussenElektra 100%	PWR; 1,410	a) 16.09.1978 b) 06.08.2011 c) 04.05.2012
3	Grafenrheinfeld (KKG); Grafenrheinfeld Bavaria	a) PreussenElektra b) KWU c) PreussenElektra 100%	PWR 1,345	a) 09.12.1981 b) 31.12.2015*) c) 28.03.2014
4	Krümmel (KKK); Krümmel Schleswig-Holstein	a) Kernkraftwerk Krümmel b) KWU c) VENE 50%, PreussenElektra 50%	BWR; 1,402	a) 14.09.1983 b) 06.08.2011 c) 24.08.2015

**) Date of final shutdown: 27.06.2015*

(d) National laws and regulations

The structure and sequence of the following references are based on the "Handbook on Nuclear Safety and Radiation Protection". As a general rule, the laws and regulations listed in the Handbook must be taken into account during licensing and supervisory procedures by the regulatory body. The list contains only those regulations that are relevant directly or by appropriate application in connection with the treatment of spent fuel and radioactive waste, and that are cited in this report. For this reason there are gaps in the numbering of the references and the numbering does not correspond exactly with the Handbook. The complete handbook is currently available at www.bfe.bund.de ("Laws and regulations").

1 Regulations

- 1A National nuclear and radiation protection regulations
- 1B Regulations concerning the safety of nuclear facilities
- 1C Regulations for the transport of radioactive material and accompanying regulations
- 1D Bilateral agreements in the nuclear field and in the area of radiation protection
- 1E Multilateral agreements on nuclear safety and radiation protection with national implementing regulations
- 1F Law of the European Union in the area of nuclear safety and radiation protection

2 General administrative provisions

3 Announcements by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety and the formerly competent Federal Ministry for the Interior

4 Relevant recommendations of the SSK and the ESK

5 Safety standards of the Nuclear Safety Standards Commission (KTA)

1 Regulations

1A National nuclear and radiation protection regulations

[1A-2] Gesetz zur geordneten Beendigung der Kernenergienutzung zur gewerblichen Erzeugung von Elektrizität vom 22. April 2002 (BGBl. I 2002, Nr. 26, S. 1351)

[1A-3] Gesetz über die friedliche Verwendung der Kernenergie und den Schutz gegen ihre Gefahren (Atomgesetz – AtG) in der Fassung der Bekanntmachung vom 15. Juli 1985 (BGBl. I 1985, Nr. 41, S. 1565), das zuletzt durch Artikel 1 des Gesetzes vom 26. Juli 2016 (BGBl. I 2016, Nr. 37, S. 1843) geändert worden ist, berichtigt am 15. Dezember 2016 (BGBl. I 2016, Nr. 61, S. 2930)

Hinweis: Die Änderung durch Artikel 1 des Gesetzes vom 29. August 2008 (BGBl. I 2008, Nr. 40, S. 1793) tritt erst in Kraft, wenn das Protokoll vom 12. Februar 2004 zur Änderung des Übereinkommens vom 29. Juli 1960 über die Haftung gegenüber Dritten auf dem Gebiet der Kernenergie in der Fassung des Zusatzprotokolls vom 28. Januar 1964 und des Protokolls vom 16. November 1982 nach seinem Artikel 20 in Kraft tritt (vgl. 1E-5.1 Pariser Übereinkommen).

[1A-4] Fortgeltendes Recht der Deutschen Demokratischen Republik aufgrund von Artikel 9 Abs. 2 in Verbindung mit Anlage II Kapitel XII Abschnitt III Nr. 2 und 3 des Einigungsvertrages vom 31. August 1990 in Verbindung mit Artikel 1 des Gesetzes zum Einigungsvertrag vom 23. September 1990 (BGBl. II 1990, Nr. 35, S. 885 und 1226), soweit dabei radioaktive Stoffe, insbesondere Radonfolgeprodukte, anwesend sind:

- Verordnung über die Gewährleistung von Atomsicherheit und Strahlenschutz – AtStrlSV – vom 11. Oktober 1984 (GBl. (DDR) I 1984, Nr. 30, S. 341) und Durchführungsbestimmung zur Verordnung über die Gewährleistung von Atomsicherheit und Strahlenschutz – AtStrlSVDBest – vom 11. Oktober 1984 (GBl. (DDR) I 1984, Nr. 30, S. 348, berichtigt GBl. (DDR) I 1987, Nr. 18, S. 196)

Anordnung zur Gewährleistung des Strahlenschutzes bei Halden und industriellen Absetzanlagen und bei Verwendung darin abgelagerter Materialien – StrSAblAnO – vom 17. November 1980 (GBl. (DDR) I 1980, Nr. 34, S. 347)

[1A-5] Gesetz zum vorsorgenden Schutz der Bevölkerung gegen Strahlenbelastung (Strahlenschutz-vorsorgegesetz – StrVG) vom 19. Dezember 1986 (BGBl. I, Nr. 69, S. 2610), zuletzt geändert durch Artikel 91 der Verordnung vom 31. August 2015 (BGBl. I 2015, Nr. 35, S. 1474)

[1A-7a] Gesetz zur Suche und Auswahl eines Standortes für ein Endlager für Wärme entwickelnde radioaktive Abfälle und zur Änderung anderer Gesetze (Standortauswahlgesetz – StandAG) vom 23. Juli 2013 (BGBl. I 2013, Nr. 41, S. 2553), zuletzt geändert durch Artikel 309 der Verordnung vom 31. August 2015 (BGBl. I 2015, Nr. 35, S. 1474)

[1A-7b] Gesetz zur Fortentwicklung des Gesetzes zur Suche und Auswahl eines Standortes für ein Endlager für Wärme entwickelnde radioaktive Abfälle und andere Gesetze vom 5. Mai 2017 (BGBl. I 2017, Nr. 26, S. 1074)

[1A-8] Verordnung über den Schutz vor Schäden durch ionisierende Strahlen (Strahlenschutzverordnung – StrlSchV) vom 20. Juli 2001 (BGBl. I 2001, Nr. 38, S. 1714), berichtigt am 22. April 2002 (BGBl. I 2002, Nr. 27, S. 1459), zuletzt geändert durch Artikel 8 des Gesetzes vom 26. Juli 2016 (BGBl. I S. 1843)

Hinweis: geändert durch Artikel 2 des Gesetzes vom 29. August 2008 (BGBl. I 2008, Nr. 40, S. 1793), diese Änderung tritt erst in Kraft, wenn das Protokoll vom 12. Februar 2004 zur Änderung des Übereinkommens vom 29. Juli 1960 über die Haftung gegenüber Dritten auf dem Gebiet der Kernenergie in der Fassung des Zusatzprotokolls vom 28. Januar 1964 und des Protokolls vom 16. November 1982 nach seinem Artikel 20 in Kraft tritt

[1A-10] Verordnung über das Verfahren bei der Genehmigung von Anlagen nach § 7 des Atomgesetzes (Atomrechtliche Verfahrensverordnung – AtVfV) vom 3. Februar 1995 (BGBl. I 1995, Nr. 8, S. 180), zuletzt geändert durch Artikel 4 des Gesetzes vom 9. Dezember 2006 (BGBl. I 2006, Nr. 58, S. 2819)

[1A-11] Verordnung über die Deckungsvorsorge nach dem Atomgesetz (Atomrechtliche Deckungsvorsorge-Verordnung – AtDeckV) vom 25. Januar 1977 (BGBl. I 1977, Nr. 8, S. 220), zuletzt geändert durch Artikel 74 des Gesetzes vom 8. Juli 2016 (BGBl. I 2016, Nr. 34, S. 1594)

[1A-13] Verordnung über Vorausleistungen für die Einrichtung von Anlagen des Bundes zur Sicherstellung und zur Endlagerung radioaktiver Abfälle (Endlagervorausleistungsverordnung – EndlagerVlV) vom 28. April 1982 (BGBl. I, Nr. 16, S. 562), die zuletzt durch Artikel 9 des Gesetzes vom 26. Juli 2016 (BGBl. I 2016, Nr. 37, S. 1843) geändert worden ist

Hinweis: Die Änderung durch Artikel 5 des Gesetzes vom 27. Januar 2017 (BGBl. I 2017, Nr. 5, S. 114) tritt erst an dem Tag in Kraft, an dem die Europäische Kommission die beihilferechtliche Genehmigung erteilt oder verbindlich mitteilt, dass eine solche Genehmigung nicht erforderlich ist; das Bundesministerium für Wirtschaft und Energie gibt den Tag des Inkrafttretens im Bundesgesetzblatt bekannt

[1A-17] Verordnung über den kerntechnischen Sicherheitsbeauftragten und über die Meldungen von Störfällen und sonstigen Ereignissen (Atomrechtliche Sicherheitsbeauftragten- und Meldeverordnung – AtSMV) vom 14. Oktober 1992 (BGBl. I 1992, Nr. 48, S. 1766), zuletzt geändert durch Artikel 1 der Verordnung vom 8. Juni 2010 (BGBl. I 2010, Nr. 31, S. 755)

[1A-18] Verordnung über die Verbringung radioaktiver Abfälle oder abgebrannter Brennelemente (Atomrechtliche Abfallverbringungsverordnung – AtAV) vom 30. April 2009 (BGBl. I 2009, Nr. 24, S. 1000), zuletzt geändert durch Artikel 76 des Gesetzes vom 8. Juli 2016 (BGBl. I 2016, Nr. 34, S. 1594)

[1A-19] Verordnung für die Überprüfung der Zuverlässigkeit zum Schutz gegen Entwendung oder Freisetzung radioaktiver Stoffe nach dem Atomgesetz (Atomrechtliche Zuverlässigkeitsüberprüfungs-Verordnung – AtZüV) vom 1. Juli 1999 (BGBl. I 1999, Nr. 35, S. 1525), die zuletzt durch Artikel 10 des Gesetzes vom 26. Juli 2016 (BGBl. I 2016, Nr. 37, S. 1843) geändert worden ist

[1A-23] Gesetz zur Kontrolle hochradioaktiver Strahlenquellen vom 12. August 2005 (BGBl. I 2005, Nr. 49, S. 2365), berichtigt am 11. Oktober 2005 (BGBl. I 2005, Nr. 64, S. 2976)

Hinweis: Umsetzung der Richtlinie 2003/122/EURATOM vom 22. Dezember 2003 zur Kontrolle hochradioaktiver umschlossener Strahlenquellen und herrenloser Strahlenquellen

[1A-24] Zehntes Gesetz zur Änderung des Atomgesetzes vom 17. März 2009 (BGBl. I 2009, Nr. 15, S. 556)

[1A-25] Dreizehntes Gesetz zur Änderung des Atomgesetzes vom 31. Juli 2011 (BGBl. I 2011, Nr. 43, S. 1704)

[1A-26] Gesetz zur Beschleunigung der Rückholung radioaktiver Abfälle und der Stilllegung der Schachtanlage Asse II vom 20. April 2013 (AtGÄndG) (BGBl. I 2013, Nr. 19, S. 921)

[1A-27] Gesetz über die Errichtung eines Bundesamtes für kerntechnische Entsorgungssicherheit – BfkEG – vom 23. Juli 2013 (BGBl. I 2013, Nr. 41, S. 2553), geändert durch Artikel 310 der Verordnung vom 31. August 2015 (BGBl. I 2015, Nr. 35, S. 1474)

[1A-28] Vierzehntes Gesetz zur Änderung des Atomgesetzes vom 20. November 2015 (BGBl. I 2015, Nr. 46, S. 2053)

Hinweis: Umsetzung weiterer Vorgaben der Richtlinie 2011/70/EURATOM vom 19. Juli 2011 über einen Gemeinschaftsrahmen für die verantwortungsvolle und sichere Entsorgung abgebrannter Brennelemente und radioaktiver Abfälle

[1A-29a] Gesetz zur Neuordnung des Rechts zum Schutz vor der schädlichen Wirkung ionisierender Strahlung, Bundesrat Beschlussdrucksache 342/17(B) (12. Mai 2017)

[1A-29b] Gesetz zur Neuordnung des Rechts zum Schutz vor der schädlichen Wirkung ionisierender Strahlung – Artikel 1: Gesetz zum Schutz vor der schädlichen Wirkung ionisierender Strahlung (Strahlenschutzgesetz – StrlSchG), Bundesrat Beschlussdrucksache 342/17(B) (12. Mai 2017)

[1A-30] Gesetz zur Neuordnung der Organisationsstruktur im Bereich der Endlagerung (EndLaNOG) vom 26. Juli 2016 (BGBl. I 2016, Nr. 37, S. 1843), zuletzt geändert durch die Berichtigung des Gesetzes zur Neuordnung der Organisationsstruktur im Bereich der Endlagerung vom 15. Dezember 2016 (BGBl. I 2016, Nr. 61, S. 2930)

[1A-31] Gesetz zur Neuordnung der Verantwortung in der kerntechnischen Entsorgung vom 27. Januar 2017 (BGBl. I 2017, Nr. 5, S. 114)

1B Regulations concerning the safety of nuclear facilities

[1B-1] Strafgesetzbuch – StGB – vom 13. November 1998 (BGBl. I 1998, Nr. 75, S. 3322), das zuletzt durch Artikel 2 Absatz 4 des Gesetzes vom 22. Dezember 2016 (BGBl.I 2016, Nr. 65, S. 3150) geändert worden ist

Hinweis: Die Änderungen durch Artikel 16 Absatz 8 des Gesetzes vom 30. Juni 2016 (BGBl. I 2016, Nr. 31, S. 1514) treten an dem Tag in Kraft, der dem Tag folgt, an dem in Verordnungen und Richtlinien der EU benannte technische Regulierungsstandards in Kraft treten.

[1B-2] Raumordnungsgesetz – ROG – vom 22. Dezember 2008 (BGBl. I 2008, Nr. 65, S. 2986), zuletzt geändert durch Artikel 124 der Verordnung vom 31. August 2015 (BGBl. I 2015, Nr. 35, S. 1474)

[1B-3] Gesetz zum Schutz vor schädlichen Umwelteinwirkungen durch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge (Bundes-Immissionsschutzgesetz – BImSchG) in der Fassung der Bekanntmachung vom 17. Mai 2013 (BGBl.I 2013, Nr. 25, S. 1274), das zuletzt durch Artikel 1 des Gesetzes vom 30. November 2016 (BGBl.I 2016, Nr. 57, S. 2749) geändert worden ist

[1B-5] Gesetz zur Ordnung des Wasserhaushalts (Wasserhaushaltsgesetz – WHG) vom 31. Juli 2009 (BGBl. I 2009, Nr. 51, S. 2585), das zuletzt durch Artikel 1 des Gesetzes vom 4. August 2016 (BGBl.I 2016, Nr. 40, S. 1972) geändert worden ist; die Änderung durch Artikel 4 Absatz 76 des Gesetzes vom 7. August 2013 (BGBl.I 2013, Nr. 48, S. 3154) tritt am 14. August 2018 in Kraft; die Änderung durch Artikel 4 Absatz 73 des Gesetzes vom 18. Juli 2016 (BGBl.I 2016, Nr. 35, S. 1666) tritt am 1. Oktober 2021 in Kraft

[1B-6] Gesetz über Naturschutz und Landschaftspflege (Bundesnaturschutzgesetz – BNatSchG) vom 29. Juli 2009 (BGBl.I 2009, Nr. 51, S. 2542), das zuletzt durch Artikel 19 des Gesetzes vom 13. Oktober 2016 (BGBl.I 2016, Nr. 49, S. 2258) geändert worden ist; die Änderung durch Artikel 4 Absatz 100 des Gesetzes vom 7. August 2013 (BGBl.I 2013, Nr. 48, S. 3154) tritt am 14. August 2018 in Kraft; die Änderung durch Artikel 4 Absatz 96 des Gesetzes vom 18. Juli 2016 (BGBl.I 2016, Nr. 35, S. 1666) tritt am 1. Oktober 2021 in Kraft

[1B-13] Gesetz zur Förderung der Kreislaufwirtschaft und Sicherung der umweltverträglichen Bewirtschaftung von Abfällen (Kreislaufwirtschaftsgesetz – KrWG) vom 24. Februar 2012 (BGBl. I 2012, Nr. 10, S. 212), zuletzt geändert durch Artikel 4 des Gesetzes vom 4. April 2016 (BGBl. I 2016, Nr. 15, S. 569)

[1B-14] Gesetz über die Umweltverträglichkeitsprüfung – UVPG – vom 24. Februar 2010 (BGBl. I 2010, Nr. 7, S. 94), zuletzt geändert durch Artikel 2 des Gesetzes vom 30. November 2016 (BGBl.I 2016, Nr. 57, S. 2749); die Änderung durch Artikel 4 des Gesetzes vom 13.Oktober 2016 (BGBl.I 2016, Nr. 49, S. 2258) tritt am 1. Januar 2017 in Kraft

Hinweis: Umsetzung der Richtlinie 2011/92/EU vom 13. Dezember 2011 (ABl. 2012, L 26) und der Richtlinie 2001/42/EG vom 27. Juni 2001 (ABl. 2001, L 197)

[1B-15] Bundesberggesetz – BBergG – vom 13. August 1980 (BGBl. I 1980, Nr. 48, S. 1310), das zuletzt durch Artikel 4 des Gesetzes vom 30. November 2016 (BGBl.I 2016, Nr. 57, S. 2749) geändert worden ist; die Änderung durch Artikel 4 Absatz 68 des Gesetzes vom 18. Juli 2016 (BGBl.I 2016, Nr. 35, S. 1666) tritt am 1. Oktober 2021 in Kraft

[1B-18] Baugesetzbuch (BauGB) in der Fassung der Bekanntmachung vom 23. September 2004 (BGBl. I 2004, Nr. 52, S. 2414), das zuletzt durch Artikel 6 des Gesetzes vom 29. Mai 2017 (BGBl. I S. 1298) geändert worden ist

1C Regulations for the transport of radioactive material and accompanying regulations

No references.

1D Bilateral agreements in the nuclear field and in the area of radiation protection

[1D-1] Abkommen zwischen der Bundesrepublik Deutschland und der Bundesrepublik Österreich über die gegenseitige Hilfeleistung bei Katastrophen und Unglücksfällen vom 23. Dezember 1988; Gesetz dazu vom 20. März 1992 (BGBl. II 1992, S. 206); in Kraft seit 1. Oktober 1992 (BGBl. II 1992, S. 593)

[1D-2] Abkommen zwischen der Bundesrepublik Deutschland und dem Königreich Belgien über die gegenseitige Hilfeleistung bei Katastrophen oder schweren Unglücksfällen vom 6. November 1980; Gesetz dazu vom 30. November 1982 (BGBl. II 1982, S. 1006); in Kraft seit 1. Mai 1984 (BGBl. II 1984, S. 327)

[1D-3] Abkommen zwischen der Bundesrepublik Deutschland und der Schweizerischen Eidgenossenschaft über die gegenseitige Hilfeleistung bei Katastrophen oder schweren Unglücksfällen vom 28. November 1984; Gesetz dazu vom 22. Januar 1987 (BGBl. II 1987, S. 74); in Kraft seit 1. Dezember 1988 (BGBl. II 1988, S. 967)

[1D-4] Abkommen zwischen der Bundesrepublik Deutschland und dem Königreich Dänemark über die gegenseitige Hilfeleistung bei Katastrophen oder schweren Unglücksfällen vom 16. Mai 1985; Gesetz dazu vom 17. März 1988 (BGBl. II 1988, S. 286); in Kraft seit 1. August 1988 (BGBl. II 1988, S. 619)

[1D-5] Abkommen zwischen der Bundesrepublik Deutschland und der Französischen Republik über die gegenseitige Hilfeleistung bei Katastrophen oder schweren Unglücksfällen vom 3. Februar 1977; Gesetz dazu vom 14. Januar 1980 (BGBl. II 1980, S. 33); in Kraft seit 1. Dezember 1980 (BGBl. II 1980, S. 1438)

[1D-6] Abkommen zwischen der Bundesrepublik Deutschland und der Regierung der Republik Ungarn über die gegenseitige Hilfeleistung bei Katastrophen und Unglücksfällen vom 9. Juni 1997; Gesetz dazu vom 7. Juli 1998 (BGBl. II 1998, S. 1189); in Kraft seit 11. September 1998 (BGBl. II 1999, S: 125)

[1D-7] Abkommen zwischen der Bundesrepublik Deutschland und der Republik Litauen über die gegenseitige Hilfeleistung bei Katastrophen oder schweren Unglücksfällen vom 15. März 1994; Gesetz dazu vom 12. Januar 1996 (BGBl. II 1996, S. 27); in Kraft seit 1. September 1996 (BGBl. II 1996, S. 1476)

[1D-8] Abkommen zwischen der Bundesrepublik Deutschland und dem Großherzogtum Luxemburg über die gegenseitige Hilfeleistung bei Katastrophen oder schweren Unglücksfällen vom 2. März 1978; Gesetz dazu vom 7. Juli 1981 (BGBl. II 1981, S. 445); in Kraft seit 1. Dezember 1981 (BGBl. II 1981, S. 1067)

[1D-9] Abkommen zwischen der Bundesrepublik Deutschland und dem Königreich der Niederlande über die gegenseitige Hilfeleistung bei Katastrophen einschließlich schweren Unglücksfällen vom 7. Juni 1988; Gesetz dazu vom 20. März 1992 (BGBl. II 1992, S. 198); in Kraft seit 1. März 1997 (BGBl. II 1997, S. 753 und S. 1392)

[1D-10] Abkommen zwischen der Bundesrepublik Deutschland und der Republik Polen über die gegenseitige Hilfeleistung bei Katastrophen oder schweren Unglücksfällen vom 10. April 1997; Gesetz dazu vom 7. Juli 1998 (BGBl. II 1998, S. 1178); in Kraft seit 1. März 1999 (BGBl. II 1999, S. 15)

[1D-11] Abkommen zwischen der Bundesrepublik Deutschland und der Russischen Föderation über die gegenseitige Hilfeleistung bei Katastrophen oder schweren Unglücksfällen vom 16. Dezember 1992; Gesetz dazu vom 19. Oktober 1994 (BGBl. II 1994, S. 3542); in Kraft seit 11. Juli 1995 (BGBl. II 1997, S. 728)

[1D-12] Vertrag zwischen der Bundesrepublik Deutschland und der Tschechischen Republik über die gegenseitige Hilfeleistung bei Katastrophen und schweren Unglücksfällen vom 19. September 2000; Gesetz hierzu vom 16. August 2002 (BGBl. II 2002, Nr. 31); in Kraft seit dem 1. Januar 2003 (BGBl. II 2003, Nr. 2)

1E Multilateral agreements on nuclear safety and radiation protection with national implementing regulations

[1E-1] Gemeinsames Übereinkommen über die Sicherheit der Behandlung abgebrannter Brennelemente und über die Sicherheit der Behandlung radioaktiver Abfälle – Übereinkommen über nukleare Entsorgung (*Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, INFCIRC/546) vom 5. September 1997, in Kraft seit 18. Juni 2001;
72 Vertragsparteien (04/16), Depositar: IAEA
Gesetz hierzu mit amtlicher Übersetzung vom 13. August 1998 (BGBl. II 1998, Nr. 31, S. 1752)
in Kraft für Deutschland seit 18. Juni 2001 (BGBl. II 2001, Nr. 36, S. 1283)

[1E-1-1] Übereinkommen über die Umweltverträglichkeitsprüfung im grenzüberschreitenden Rahmen - Espoo-Konvention (Convention on the Environmental Impact Assessment in a Transboundary Context - EIA) vom 25. Februar 1991, in Kraft seit 10. September 1997

45 Vertragsparteien (07/16), Depositar: UN

1. Änderung der Espoo-Konvention vom 27. Februar 2001, in Kraft seit 26. August 2014

29 Vertragsparteien (07/16), Depositar: UN

2. Änderung der Espoo-Konvention vom 4. Juni 2004, noch nicht in Kraft, zwischen Deutschland, Österreich, Schweiz und Lichtenstein abgestimmte deutsche Übersetzung

28 Vertragsparteien (07/16), Depositar: UN

Gesetz zur Espoo-Konvention und der 1. Änderung mit amtlicher Übersetzung (Espoo-Vertragsgesetz) vom 7. Juni 2002 (BGBl.II 2002, Nr. 22, S. 1406)

Espoo-Konvention in Kraft für Deutschland seit 6. November 2002

1. Änderung der Espoo-Konvention in Kraft für Deutschland seit 26. August 2014 (BGBl.II 2014, Nr. 24, S. 758)

Gesetz zur 2. Änderung mit amtlicher Übersetzung (Zweites Espoo-Vertragsgesetz) vom 17. März 2006 (BGBl.II 2006, Nr. 7, S. 224)

[1E-3-1] Übereinkommen über die Verhütung von Meeresverschmutzung durch das Einbringen von Abfällen und anderen Stoffen – London Dumping Convention LDC (*Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter*, INFCIRC/205) vom 29. Dezember 1972, in Kraft seit 30. August 1975, mit seither 5 Änderungen
87 Vertragsparteien (06/16)
Gesetz hierzu vom 11. Februar 1977 (BGBl. II 1977, Nr. 8, S. 165), zuletzt geändert durch Gesetz vom 25. August 1998 (BGBl. I, Nr. 57, S. 2455)
in Kraft für Deutschland seit 8. Dezember 1977 (BGBl. II 1979, Nr. 13, S. 273)
Protokoll LCProt1996 (IMO) vom 7. November 1996 zu diesem Übereinkommen (ersetzt die ursprüngliche Konvention), in Kraft seit 24. März 2006, Änderung vom 2. November 2006, diese in Kraft seit 10. Februar 2007
47 Vertragsparteien (07/16) Depositare: Mexiko, Russische Förderation, UK, USA
Gesetz dazu vom 9. Juli 1998 (BGBl. II 1998, Nr. 25, S. 1345), zuletzt geändert durch Verordnung vom 24. August 2010 (BGBl. II 2010, Nr. 24, S. 1006)
Protokoll LCProt1996 in Kraft für Deutschland seit 24. März 2006 (BGBl. II 2010, Nr. 35, S. 1429)
Hinweis: Keine Einbringung von Materialien mit Radioaktivitätswerten oberhalb de-minimis-Konzentrationen

[1E-11] Übereinkommen über die Haftung gegenüber Dritten auf dem Gebiet der Kernenergie – Pariser Übereinkommen (*Convention on Third Party Liability in the Field of Nuclear Energy – Paris Convention*) vom 29. Juli 1960, ergänzt durch das Protokoll vom 28. Januar 1964 in Kraft seit 1. April 1968,
ergänzt durch das Protokoll vom 16. November 1982, das Protokoll vom 12. Februar 1982, in Kraft seit 7. April 1988
und ergänzt durch das Protokoll vom 12. Februar 2004, noch nicht in Kraft
16 Vertragsparteien (11/15), Depositar: OECD
Gesetz dazu vom 8. Juli 1975 (BGBl. II 1975, Nr. 42, S. 957), zuletzt geändert durch Artikel 30 des Gesetzes vom 9. September 2001 (BGBl. I 2001, Nr. 47, S. 2331)
in Kraft für Deutschland seit 30. September 1975 (BGBl. II 1976, Nr. 12, S. 308),

Gesetz dazu vom 21. Mai 1985 (BGBl. II 1985, Nr. 19, S. 690)
in Kraft für Deutschland seit 7. Oktober 1988 (BGBl. II 1989, Nr. 6, S. 144)
Gesetz zum Protokoll 2004 mit amtlicher Übersetzung vom 29. August 2008 (BGBl. II 2008, Nr. 24, S. 902)
Hinweis: Die Bestimmungen des Pariser Atomhaftungs-Übereinkommens gelten in Verbindung mit §§ 25 ff. des Atomgesetzes in der Bundesrepublik Deutschland unmittelbar, d. h. die Haftung für nukleare Schäden bestimmt sich nach den Bestimmungen des Übereinkommens in Verbindung mit dem Atomgesetz.

[1E-12] Zusatzübereinkommen zum Pariser Übereinkommen vom 29. Juli 1960 – Brüsseler Zusatzübereinkommen, (Convention Supplementary to the Paris Convention of 29 July 1960 on Third Party Liability in the Field of Nuclear Energy – Brussels Supplementary Convention) vom 31. Januar 1963, ergänzt durch das Protokoll vom 28. Januar 1964, in Kraft seit 4. Dezember 1974,
ergänzt durch das Protokoll vom 16. November 1982, in Kraft seit 1. August 1991
und ergänzt durch das Protokoll von 2004, noch nicht in Kraft
12 Vertragsparteien (3/15), Depositar: OECD
Gesetz dazu vom 8. Juli 1975 (BGBl. II 1975, Nr. 42, S. 957), zuletzt geändert durch Artikel 30 des Gesetzes vom 9. September 2001 (BGBl. I 2001, Nr. 47, S. 2331)
in Kraft für Deutschland seit 1. Januar 1976 (BGBl. II 1976, Nr. 12, S. 308)
Gesetz dazu vom 21. Mai 1985 (BGBl. II 1985, Nr. 19, S. 690)
in Kraft für Deutschland seit 1. August 1991 (BGBl. II 1995, Nr. 24, S. 657)
Gesetz zum Protokoll 2004 mit amtlicher Übersetzung vom 29. August 2008 (BGBl. II 2008, Nr. 24, S. 902)
Hinweis: Im Brüsseler Zusatzübereinkommen verpflichten sich die Vertragsparteien, bei Schäden, die über den Haftungsbetrag des haftpflichtigen Inhabers der Kernanlage hinausgehen, weitere Entschädigungsbeträge aus öffentlichen Mitteln bereitzustellen. Dieses Übereinkommen gilt in der Bundesrepublik Deutschland nicht unmittelbar, sondern schafft nur völkerrechtliche Verpflichtungen zwischen den Vertragsstaaten.

1F Law of the European Union

Agreements, general provisions

[1F-1] Vertrag vom 25. März 1957 zur Gründung der Europäischen Atomgemeinschaft EURATOM (BGBl. II 1957, S. 1014, berichtigt S. 1678; berichtigt BGBl. II 1999, S. 1024), Konsolidierte Fassung 2016
Der Vertrag ist in seiner ursprünglichen Fassung am 1. Januar 1958 in Kraft getreten (BGBl. II 1958 S. 1), die Neufassung trat am 1. November 1993 in Kraft (BGBl. II 1993, S. 1947), Berichtigung der Übersetzung des EURATOM-Vertrages vom 13. Oktober 1999 (BGBl. II 1999, Nr. 31)

[1F-5] Richtlinie 2009/71/EURATOM des Rates vom 25. Juni 2009 über einen Gemeinschaftsrahmen für die nukleare Sicherheit kerntechnischer Anlagen (ABl. 2009 L172), zuletzt geändert durch die Richtlinie des Rates 2014/87/EURATOM vom 8. Juli 2014 (ABl. 2015, L 219), konsolidierte Fassung 2014

[1F-12] Richtlinie 2011/92/EU des Europäischen Parlaments und des Rates über die Umweltverträglichkeitsprüfung bei bestimmten öffentlichen und privaten Projekten vom 13. Dezember 2011 (ABl. 2012, L 26), geändert, letzte konsolidierte Fassung 2014
Hinweis: Umsetzung vgl. UVP-Gesetz

[1F-14] Verordnung (EURATOM) 302/2005 der Kommission vom 8. Februar 2005 über die Anwendung der EURATOM-Sicherungsmaßnahmen (ABl. 2005, L 54) zuletzt geändert durch die Verordnung (EU) 519/2013 der Kommission vom 21. Februar 2013 (ABl. 2013, L 158), letzte konsolidierte Fassung 2013

Radiation protection

[1F-18] Richtlinien des Rates, mit denen die Grundnormen für den Gesundheitsschutz der Bevölkerung und der Arbeitskräfte gegen die Gefahren ionisierender Strahlungen festgelegt wurden (EURATOM-Grundnormen)

- Richtlinie vom 2. Februar 1959 (ABl. EG 1959, Nr. 11),
- Richtlinie vom 5. März 1962 (ABl. EG 1962, S. 1633/62),
- Richtlinie 66/45/EURATOM (ABl. EG 1966, Nr. 216),
- Richtlinie 76/579/EURATOM vom 1. Juni 1976 (ABl. EG 1976, Nr. L187),
- Richtlinie 79/343/EURATOM vom 27. März 1977 (ABl. EG 1979, Nr. L83),
- Richtlinie 80/836/EURATOM vom 15. Juli 1980 (ABl. EG 1980, Nr. L246),
- Richtlinie 84/467/EURATOM vom 3. September 1984 (ABl. EG 1984, Nr. L265),
- Neufassung mit Berücksichtigung der ICRP 60 in Richtlinie 96/29/EURATOM vom 13. Mai 1996 (ABl. EG 1996, Nr. L159)

[1F-20] Richtlinie 90/641/EURATOM des Rates vom 4. Dezember 1990 über den Schutz externer Arbeitskräfte, die einer Gefährdung durch ionisierende Strahlung bei Einsatz im Kontrollbereich ausgesetzt sind (ABl. EG 1990, Nr. L349)

[1F-22] Richtlinie 2003/122/EURATOM des Rates vom 22. Dezember 2003 zur Kontrolle hoch radioaktiver umschlossener Strahlenquellen und herrenloser Strahlenquellen (ABl. 2003, Nr. L346 vom 31. Dezember 2003 S. 57-66)
Hinweise: Ausgenommen sind Tätigkeiten, die unter den EURATOM-Vertrag oder eines der speziellen Nuklearhaftungsregime fallen. Die Richtlinie 2003/122/EURATOM wird mit Wirkung zum 6. Februar 2018 aufgehoben durch die Richtlinie 2013/59/EURATOM.

[1F-23] Richtlinie 97/43/EURATOM des Rates vom 30. Juni 1997 über den Gesundheitsschutz von Personen gegen die Gefahren ionisierender Strahlung bei medizinischer Exposition und zur Aufhebung der Richtlinie 84/466/EURATOM (ABl. 1997, L180)

[1F-24] Richtlinie 2013/59/EURATOM des Rates vom 5. Dezember 2013 zur Festlegung grundlegender Sicherheitsnormen für den Schutz vor den Gefahren einer Exposition gegenüber ionisierender Strahlung und zur Aufhebung der Richtlinien 89/618/EURATOM, 90/641/EURATOM, 96/29/EURATOM, 97/43/EURATOM und 2003/122/EURATOM (ABl. 2014, L13)

Radiological emergencies

[1F-29] Richtlinie 89/618/EURATOM des Rates vom 27. November 1989 über die Unterrichtung der Bevölkerung über die bei einer radiologischen Notstandssituation geltenden Verhaltensmaßregeln und zu ergreifenden Gesundheitsschutzmaßnahmen (ABl. EG 1989, Nr. L357)

- Mitteilung der Kommission betreffend die Durchführung der Richtlinie 89/618/EURATOM (ABl. EG 1991, Nr. C103)

Hinweis: wird ab 6. Februar 2018 aufgehoben durch Richtlinie 2013/59/EURATOM

Waste, hazardous materials

[1F-34] Verordnung (EURATOM) 1493/93 des Rates vom 8. Juni 1993 über die Verbringung radioaktiver Stoffe zwischen den Mitgliedstaaten (ABl. EG 1993, Nr. L148),

- Mitteilung der Kommission vom 10. Dezember 1993 zu der Verordnung EURATOM/1493/93 (ABl. EG 1993, Nr. C335)

[1F-35] Richtlinie 2006/117/EURATOM des Rates vom 20. November 2006 über die Überwachung und Kontrolle der Verbringung radioaktiver Abfälle und abgebrannter Brennelemente (ABl. Nr. L337 vom 5. Dezember 2006, S. 21)

[1F-36] Richtlinie 2011/70/EURATOM des Rates vom 19. Juli 2011 über einen Gemeinschaftsrahmen für die verantwortungsvolle und sichere Entsorgung abgebrannter Brennelemente und radioaktiver Abfälle (ABl. Nr. L199 vom 2. August 2001, S. 48)

2 General administrative provisions (excerpt)

[2-1] Allgemeine Verwaltungsvorschrift zu § 47 Strahlenschutzverordnung (Ermittlung der Strahlenexposition durch die Ableitung radioaktiver Stoffe aus Anlagen oder Einrichtungen) vom 28. August 2012 (BAnz AT 05.09.2012 B1)

[2-2] Allgemeine Verwaltungsvorschrift zu § 40 Abs. 2, § 95 Abs. 3 StrlSchV und § 35 Abs. 2 RöV (AVV Strahlenpass) vom 20. Juli 2004 (BAnz. 2004, Nr. 142a)

[2-3] Allgemeine Verwaltungsvorschrift zur Ausführung des Gesetzes über die Umweltverträglichkeitsprüfung (UVPVwV) vom 18. September 1995 (GMBl. 1995, Nr. 32, S. 671)

[2-4] Allgemeine Verwaltungsvorschrift zum Integrierten Mess- und Informationssystem zur Überwachung der Radioaktivität in der Umwelt nach dem Strahlenschutzvorsorgegesetz (AVV-IMIS) vom 13. Dezember 2006 (BAnz. 2006, Nr. 244a)

[2-5] Allgemeine Verwaltungsvorschrift zur Durchführung der Überwachung von Lebensmitteln nach der Verordnung (EURATOM) Nr. 3954/87 des Rates vom 22. Dezember 1987 zur Festlegung von Höchstwerten an Radioaktivität in Nahrungsmitteln und Futtermitteln im Falle eines nuklearen Unfalls oder einer anderen radiologischen Notstandssituation (AVV-Strahlenschutzvorsorge-Lebensmittelüberwachung – AW-StrahLe) vom 28. Juni 2000 (GMBl. 2000, Nr. 25, S. 490)

[2-6] Allgemeine Verwaltungsvorschrift zur Überwachung der Höchstwerte für Futtermittel nach der Verordnung (EURATOM) Nr. 3954/87 des Rates vom 22. Dezember 1987 zur Festlegung von Höchstwerten an Radioaktivität in Nahrungsmitteln und Futtermitteln im Falle eines nuklearen Unfalls oder einer anderen radiologischen Notstandssituation (Futtermittel-Strahlenschutzvorsorge-Verwaltungsvorschrift – FMStrVVwV) vom 22. Juni 2000 (BAnz. 2000, Nr. 122)

[2-7] Allgemeine Verwaltungsvorschrift für die Durchführung des Schnellwarnsystems für Lebensmittel, Lebensmittelbedarfsgegenstände und Futtermittel (AVV Schnellwarnsystem - AVV SWS) vom 8. September 2016 (GMBl. 2016, Nr. 39, S. 770)

3 Announcements by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety and the formerly competent Federal Ministry for the Interior (excerpt)

[3-0-1] Sicherheitsanforderungen an Kernkraftwerke vom 22. November 2012, Neufassung vom 3. März 2015 (BAnz AT 30.03.2015 B2)

[3-0-2] Interpretationen zu den Sicherheitsanforderungen an Kernkraftwerke vom 29. November 2013 (BAnz AT 10.12.2013 B4), geändert am 3. März 2015 (BAnz AT 30.03.2015 B3)

[3-2] Richtlinie für den Fachkundenachweis von Kernkraftwerkspersonal vom 24. Mai 2012 (GMBl. 2012, Nr. 34, S. 611)

[3-13] Sicherheitskriterien für die Endlagerung radioaktiver Abfälle in einem Bergwerk vom 20. April 1983 (GMBl. 1983, Nr. 13, S. 220), in Überarbeitung

[3-15] 1. Rahmenempfehlungen für den Katastrophenschutz in der Umgebung kerntechnischer Anlagen vom 27. Oktober 2008 (GMBl. 2008, Nr. 62/63, S. 1278), ersetzt durch Rahmenempfehlungen der SSK für den Katastrophenschutz in der Umgebung kerntechnischer Anlagen
2. Radiologische Grundlagen für Entscheidungen über Maßnahmen zum Schutz der Bevölkerung bei unfallbedingten Freisetzungen von Radionukliden vom 27. Oktober 2008 (GMBl. 2008, Nr. 62/63, S. 1278) mit der Anlage „Verwendung von Jodtabletten zur Jodblockade der Schilddrüse bei einem kerntechnischen Unfall“

[3-23] Richtlinie zur Emissions- und Immissionsüberwachung kerntechnischer Anlagen (REI) vom 7. Dezember 2005 (GMBl. 2006, Nr. 14-17, S. 254)

[3-27] Richtlinie über die Gewährleistung der notwendigen Kenntnisse der beim Betrieb von Kernkraftwerken sonst tätigen Personen vom 30. November 2000 (GMBl. 2001, Nr. 8, S. 153)

[3-33-2] Störfallberechnungsgrundlagen für die Leitlinien zur Beurteilung der Auslegung von Kernkraftwerken mit DWR gemäß § 28 Abs. 3 StrlSchV vom 18. Oktober 1983 (BAnz. 1983, Nr. 245a), Fassung des Kapitels 4 „Berechnung der Strahlenexposition“ vom 29. Juni 1994 (BAnz. 1994, Nr. 222a), Neufassung des Kapitels 4 „Berechnung der Strahlenexposition“ gemäß § 49 StrlSchV vom 20. Juli 2001 verabschiedet auf der 186. Sitzung der Strahlenschutzkommission am 11. September 2003, veröffentlicht in der Reihe „Berichte der Strahlenschutzkommission“, Heft 44, 2004

[3-34] Rahmenrichtlinie über die Gestaltung von Sachverständigengutachten in atomrechtlichen Verwaltungsverfahren vom 15. Dezember 1983 (GMBl. 1984, Nr. 2, S. 21)

[3-40] Richtlinie über die im Strahlenschutz erforderliche Fachkunde (Fachkunderichtlinie Technik nach StrlSchV) vom 21. Juni 2004 (GMBl. 2004, Nr. 40/41, S. 779), Änderung vom 19. April 2006 (GMBl. 2006, Nr. 38, S. 735)

[3-42-1] Richtlinie für die physikalische Strahlenschutzkontrolle zur Ermittlung der Körperdosen
Teil 1: Ermittlung der Körperdosis bei äußerer Strahlenexposition (§§ 40, 41, 42 StrlSchV; §§ 35 RöV) vom 8. Dezember 2003 (GMBl. 2004, Nr. 22, S. 410)

[3-42-2] Richtlinie für die physikalische Strahlenschutzkontrolle zur Ermittlung der Körperdosen
Teil 2: Ermittlung der Körperdosis bei innerer Strahlenexposition (Inkorporationsüberwachung) (§§ 40, 41 und 42 StrlSchV) vom 12. Januar 2007 (GMBl. 2007, Nr. 31/32, S. 623), Anhänge 1 bis 6, Anhang 7.1, Anhang 7.2, Anhang 7.3, Anhang 7.4
Hinweis: hiermit wird die Richtlinie über Anforderungen an Inkorporationsmeßstellen vom 30. September 1996 (GMBl. 1996, Nr. 46, S. 996) aufgehoben und ersetzt.

[3-43-2] Richtlinie für den Strahlenschutz des Personals bei Tätigkeiten der Instandhaltung, Änderung, Entsorgung und des Abbaus in kerntechnischen Anlagen und Einrichtungen:
Teil 2: Die Strahlenschutzmaßnahmen während des Betriebs und der Stilllegung einer Anlage oder Einrichtung – IWRS II vom 17. Januar 2005 (GMBl. 2005, Nr. 13, S. 258)

[3-59] Richtlinie zur Kontrolle radioaktiver Abfälle mit vernachlässigbarer Wärmeentwicklung, die nicht an eine Landessammelstelle abgeliefert werden vom 16. Januar 1989 (BAnz. 1989, Nr. 63a), letzte Ergänzung vom 14. Januar 1994 (BAnz. 1994, Nr. 19)
Hinweis: Inhaltlich ersetzt durch Richtlinie zur Kontrolle radioaktiver Reststoffe und radioaktiver Abfälle vom 19. November 2008 [vgl. 3-60], aber offiziell nicht zurückgezogen

[3-60] Richtlinie zur Kontrolle radioaktiver Reststoffe und radioaktiver Abfälle vom 19. November 2008 (BAnz. 2008, Nr. 197)

[3-62] Richtlinie über Maßnahmen für den Schutz von Anlagen des Kernbrennstoffkreislaufs und sonstigen kerntechnischen Einrichtungen gegen Störmaßnahmen oder sonstige Einwirkungen zugangsberechtigter Einzelpersonen vom 28. Januar 1991 (GMBl. 1991, Nr. 9, S. 228)

[3-73] Leitfaden zur Stilllegung, zum sicheren Einschluss und zum Abbau von Anlagen oder Anlagenteilen nach § 7 des Atomgesetzes
vom 23. Juni 2016 (BAnz. AT 19.07.2016 B7)

4 Relevant recommendations of the SSK and the ESK

The recommendations of the SSK and the ESK can be downloaded from the websites www.ssk.de or www.entsorgungskommission.de under “Consultation Results“.

[4-2] Leitlinien für die trockene Zwischenlagerung bestrahlter Brennelemente und Wärme entwickelnder radioaktiver Abfälle in Behältern, Empfehlung der ESK, revidierte Fassung vom 10.06.2013

[4-3] ESK-Leitlinien für die Zwischenlagerung von radioaktiven Abfällen mit vernachlässigbarer Wärmeentwicklung, revidierte Fassung vom 10.06.2013

[4-4] Leitlinien zur Stilllegung kerntechnischer Anlagen, Empfehlung der Entsorgungskommission vom 16.03.2015

[4-5] ESK-Empfehlungen für Leitlinien zur Durchführung von periodischen Sicherheitsüberprüfungen für Zwischenlager für bestrahlte Brennelemente und Wärme entwickelnde radioaktive Abfälle (PSÜ-ZL), Anlage zum Ergebnisprotokoll der 14. Sitzung der Entsorgungskommission am 4. November 2010

[4-5a] ESK-Leitlinien zur Durchführung von periodischen Sicherheitsüberprüfungen und zum technischen Alterungsmanagement für Zwischenlager für bestrahlte Brennelemente und Wärme entwickelnde radioaktive Abfälle, Empfehlung der Entsorgungskommission vom 13.03.2014

[4-11] ESK-Stresstest für Anlagen und Einrichtungen der Ver- und Entsorgung in Deutschland,
Teil 1: Anlagen der Brennstoffversorgung, Zwischenlager für bestrahlte Brennelemente und Wärme entwickelnde radioaktive Abfälle, Anlagen zur Behandlung bestrahlter Brennelemente Stellungnahme der Entsorgungskommission vom 14.03.2013
Teil 2: Lager für schwach- und mittelradioaktive Abfälle, stationäre Einrichtungen zur Konditionierung schwach- und mittelradioaktiver Abfälle, Endlager für radioaktive Abfälle Stellungnahme der Entsorgungskommission vom 18.10.2013 (revidierte Fassung)

[4-11a] Langzeitsicherheitsnachweis für das Endlager für radioaktive Abfälle Morsleben (ERAM) Stellungnahme der Entsorgungskommission vom 31.01.2013

[4-11b] Radiologische Anforderungen an die Langzeitsicherheit des Endlagers für radioaktive Abfälle Morsleben (ERAM)
Empfehlung der SSK vom 15.12.2010

[4-13] Stand der Vorbereitungen hinsichtlich der Bereitstellung radioaktiver Abfallgebinde für das Endlager Konrad
Stellungnahme der Entsorgungskommission vom 02.07.2014

[4-14] Rückführung verglaster Abfälle aus der Wiederaufarbeitung im europäischen Ausland – Aufbewahrung der verglasten Abfälle in Standortzwischenlagern aufgrund der Änderung des Atomgesetzes am 01.01.2014 (§ 9a Absatz 2a AtG)
Stellungnahme der Entsorgungskommission vom 30.10.2014

[4-15] Leitlinien zur Stilllegung kerntechnischer Anlagen
Empfehlung der Entsorgungskommission vom 16.03.2015

[4-16] Umsetzung der ESK-Leitlinien für die Zwischenlagerung radioaktiver Abfälle mit vernachlässigbarer Wärmeentwicklung
Stellungnahme der Entsorgungskommission vom 07.05.2015

[4-17] Leitlinie zum sicheren Betrieb eines Endlagers für insbesondere Wärme entwickelnde radioaktive Abfälle
Empfehlung der Entsorgungskommission vom 10.12.2015

[4-18] Anforderungen an Endlagergebinde zur Endlagerung Wärme entwickelnder radioaktiver Abfälle
Empfehlung der Entsorgungskommission vom 17.03.2016

[4-19] Endlagerforschung in Deutschland: Anmerkungen zu Forschungsinhalten und Forschungssteuerung
Stellungnahme der Entsorgungskommission vom 12.05.2016

[4-20] Diskussionspapier zur verlängerten Zwischenlagerung bestrahlter Brennelemente und sonstiger Wärme entwickelnder radioaktiver Abfälle
Diskussionspapier der Entsorgungskommission vom 29.10.2015

[4-21] Radiologische Grundlagen für Entscheidungen über Maßnahmen zum Schutz der Bevölkerung bei unfallbedingten Freisetzungen von Radionukliden
Empfehlung der SSK vom Mai 2009

[4-23] Diskussionspapier zur Endlagerung von Wärme entwickelnden radioaktiven Abfällen, abgereichertem Uran aus der Urananreicherung, aus der Schachtanlage Asse II rückzuholenden Abfällen und sonstigen Abfällen, die nicht in das Endlager Konrad eingelagert werden können, an einem Endlagerstandort
Diskussionspapier der Entsorgungskommission vom 12.05.2016

[4-24] Planungsgebiete für den Notfallschutz in der Umgebung von Kernkraftwerken
Empfehlung der Strahlenschutzkommission vom 13./14. Februar 2014

[4-25] Planungsgebiete für den Notfallschutz in der Umgebung stillgelegter Kernkraftwerke
Empfehlung der Strahlenschutzkommission vom 20./21. Oktober 2014

[4-26] Rahmenempfehlungen für den Katastrophenschutz in der Umgebung kerntechnischer Anlagen
Empfehlung der Strahlenschutzkommission vom 19./20. Februar 2015

[4-27] Einführung von Dosisrichtwerten (Dose Constraints) zum Schutz vor beruflicher Strahlenexposition bei der Umsetzung der Richtlinie 2013/59/Euratom in das deutsche Strahlenschutzrecht
Empfehlung der Strahlenschutzkommission vom 11./12. Dezember 2014

[4-28] Strahlenschutz bei der Stilllegung der Schachtanlage Asse II
Empfehlung der Strahlenschutzkommission vom 15./16. September 2016

5 Safety Standards of the Nuclear Safety Standards Commission (KTA)

The following standards of the Nuclear Safety Standards Commission (as at 24 May 2017) can be downloaded from www.kta-gs.de.

Standard No. KTA	Title	Status	Last version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	Engl. Transl.
1200 General, administration, organisation							
1201	Requirements for the Operating Manual	R	2015-11	29.04.2016	1978-02; 1981-03; 1985-12; 1998-06; 2009-11	-	-
1202	Requirements for the Testing Manual	R	2009-11	3a - 07.01.2010	1984-06	11.11.14	+
1203	Requirements for the Emergency Manual	R	2009-11	3a - 07.01.2010	-	10.11.15	+
1300 Occupational radiological protection							

Standard No. KTA	Title	Status	Last version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	Engl. Transl.
1301.1	Radiation Protection Considerations for Plant Personnel in the Design and Operation of Nuclear Power Plants; Part 1: Design	ÄE	2016-11	22.12.2016	1984-11; 2012-11	-	-
1301.2	Radiation Protection Considerations for Plant Personnel in the Design and Operation of Nuclear Power Plants; Part 2: Operation	R	2014-11	15.01.2015	1982-06; 1989-06 2008-11	-	-
1400 Quality assurance							
1401	General Requirements Regarding Quality Assurance	R	2013-11	17.01.2014	1980-02; 1987-12; 1996-06	-	+
1402	Integrated Management Systems for the Safe Operation of Nuclear Power Plants	R	2012-11	23.01.2013	-	-	+
1403	Ageing Management in Nuclear Power Plants	ÄE	2016-11	22.12.2016	2010-11	-	-
1404	Documentation During the Construction and Operation of Nuclear Power Plants	R	2013-11	17.01.2014	1989-06; 2001-06	-	+
1408.1	Quality Assurance for Weld Filler Materials and Welding Consumables for Pressure and Activity Retaining Systems in Nuclear Power Plants; Part 1: Qualification Testing	R	2015-11	08.01.2016 Amendment 29.04.2016	1985-06 2008-11	-	+
1408.2	Quality Assurance for Weld Filler Materials and Welding Consumables for Pressure and Activity Retaining Systems in Nuclear Power Plants; Part 2: Manufacture	R	2015-11	08.01.2016	1985-06 2008-11	-	+
1408.3	Quality Assurance for Weld Filler Materials and Welding Consumables for Pressure and Activity Retaining Systems in Nuclear Power Plants; Part 3: Processing	R	2015-11	08.01.2016	1985-06; 2008-11	-	+
1500 Radiation protection and monitoring							
1501	Stationary System for Monitoring the Local Dose Rate within Nuclear Power Plants	ÄE	2016-11	22.12.2016	1977-10; 1991-06; 2004-11; 2010-11	-	-

Standard No. KTA	Title	Status	Last version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	Engl. Transl.
1502	Monitoring Volumetric Activity of Radioactive Substances in the Inner Atmosphere of Nuclear Power Plants	ÄE	2016-11	22.12.2016	1986-06 (1502.1); 2005-11; 2013-11	-	-
(1502.2)	Monitoring Volumetric Activity of Radioactive Substances in the Inner Atmosphere of Nuclear Power Plants	SR	1989-06	229 a - 07.12.1989	-	-	+
1503.1	Monitoring Radioactivity in the Inner Atmosphere of Nuclear Power Plants; Part 2: Nuclear Power Plants with High Temperature Reactors	R	2016-11	10.03.2017	1979-02; 1993-06; 2002-06; 2013-11	-	-
1503.2	Monitoring the Discharge of Radioactive Gases and Airborne Radioactive Particulates; Part 1: Monitoring the Discharge of Radioactive Matter with the Stack Exhaust Air During Specified Normal Operation	ÄE	2016-11	22.12.2016	1999-06 2013-11	-	-
1503.3	Monitoring the Discharge of Radioactive Gases and Airborne Radioactive Particulates; Part 2: Monitoring the Discharge of Radioactive Matter with the Vent Stack Exhaust Air During Design-Basis Accidents	ÄE	2016-11	22.12.2016	1999-06; 2013-11	-	-
1504	Monitoring the Discharge of Radioactive Gases and Airborne Radioactive Particulates; Part 2: Monitoring the Discharge of Radioactive Matter with the Vent Stack Exhaust Air During Design-Basis Accidents	R	2015-11	08.01.2016	1978-06; 1994-06; 2007-11	-	-
1505	Suitability Verification of the Stationary Measurement Equipment for Radiation Monitoring	ÄE	2016-11	22.12.2016	2003-11; 2011-11	-	-
1507	Monitoring the Discharge of Radioactive Substances from Research Reactors	ÄE	2016-11	22.12.2016	1984-03; 1998-06; 2012-11	-	-

Standard No. KTA	Title	Status	Last version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	Engl. Transl.
1508	Instrumentation for Determining the Dispersion of Radioactive Substances in the Atmosphere	ÄE	2016-11	22.12.2016	1988-09; 2006-11		-
2100 Overall plant							
2101.1	Fire Protection in Nuclear Power Plants; Part 1: Basic Requirements	R	2015-11	08.01.2016	1985-12; 2000-12	-	-
2101.2	Fire Protection in Nuclear Power Plants; Part 2: Fire Protection of Structural Components	R	2015-11	08.01.2016	2000-12	-	-
2101.3	Fire Protection in Nuclear Power Plants; Part 3: Fire Protection of Mechanical and Electrical Plant Components	R	2015-11	08.01.2016	2000-12	-	-
2103	Explosion Protection in Nuclear Power Plants with Light Water Reactors (General and Case-Specific Requirements)	R	2015-11	08.01.2016	1989-06; 2000-06	-	-
2200 External hazards							
2201.1	Design of Nuclear Power Plants against Seismic Events; Part 1: Principles	R	2011-11	11 - 19.01.2012	1975-06; 1990-06	22.11.16	+
2201.2	Design of Nuclear Power Plants against Seismic Events; Part 2: Subsoil	R	2012-11	23.01.2013	1982-11; 1990-06	-	+
2201.3	Design of Nuclear Power Plants against Seismic Events; Part 3: Structural Components	R	2013-11	17.01.2014	-	-	-
2201.4	Design of Nuclear Power Plants against Seismic Events; Part 4: Components	R	2012-11	23.01.2013	1990-06	-	+
2201.5	Design of Nuclear Power Plants against Seismic Events; Part 5: Seismic Instrumentation	R	2015-11	08.01.2016	1977-06; 1990-06; 1996-06	-	-
2201.6	Design of Nuclear Power Plants against Seismic Events; Part 6: Post-Seismic Measures	R	2015-11	08.01.2016	1992-06	-	-
2206	Design of Nuclear Power Plants Against Damaging Effects from Lightning	R	2009-11	3a - 07.01.2010	1992-06; 2000-06	11.11.14	+

Standard No. KTA	Title	Status	Last version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	Engl. Transl.
2207	Flood Protection for Nuclear Power Plants	R	2004-11	35 a - 19.02.2005	1982-06; 1992-06	10.11.09; 11.11.14	+
2500 Structural engineering							
2501	Structural Waterproofing of Nuclear Power Plants	R	2015-11	29.04.2016	1988-09; 2002-06; 2004-11; 2010-11	-	+
2502	Mechanical Design of Fuel Assembly Storage Pools in Nuclear Power Plants with Light Water Reactors	R	2011-11	11 - 19.01.2012	1990-06	22.11.16	+
3000 Systems in general **3100 Reactor core and reactor control**							
3101.1	Design of Reactor Cores of Pressurized Water and Boiling Water Reactors; Part 1: Principles of Thermohy-draulic Design	ÄE	2016-11	22.12.2016	1980-02; 2012-11	-	-
3101.2	Design of Reactor Cores of Pressurized Water and Boiling Water Reactors; Part 1: Principles of Thermohy-draulic Design	R	2012-11	23.01.2013	1987-12	-	+
3101.3	Design of Reactor Cores of Pressurized Water and Boiling Water Reactors; Part 2: Neutron-Physical Requirements for Design and Operation of the Reactor Core and Adjacent Systems	R	2015-11	08.01.2016 Amendment 10.03.2017	-	-	-
(3102.1)	Design of Reactor Cores of Pressurized Water and Boiling Water Reactors; Part 3: Mechanical and Thermal Design	SR	1978-06	189 a - 06.10.1978 Suppl. 23/78	-	29.11.83; 20.09.88; 15.06.93	+
(3102.2)	Reactor Core Design for High Temperature Gas-Cooled Reactors; Part 1: Calculation of the Material Properties of Helium	SR	1983-06	194 - 14.10.1983 Suppl. 47/83	-	20.09.88; 15.06.93	+
(3102.3)	Reactor Core Design for High Temperature Gas-Cooled Reactors; Part 2: Heat Transfer in Spherical Fuel Elements	SR	1981-03	136 a - 28.07.1981 Suppl. 24/81	-	25.11.86; 12.06.91; 15.06.93	+

Standard No. KTA	Title	Status	Last version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	Engl. Transl.
(3102.4)	Reactor Core Design for High Temperature Gas-Cooled Reactors; Part 3: Loss of Pressure through Friction in Pebble Bed Cores	SR	1984-11	40 a - 27.02.1985 Amendment 124 - 07.07.89	-	27.06.93; 15.06.93	+
(3102.5)	Reactor Core Design for High Temperature Gas-Cooled Reactors; Part 4: Thermohydraulic Analytical Model for Stationary and Quasi-Stationary Conditions in Pebble Bed Cores	SR	1986-06	162 a - 03.09.1986	-	11.06.91; 15.06.93	+
3103	Reactor Core Design for High Temperature Gas-Cooled Reactors; Part 5: Systematic and Statistical Errors in the Thermohydraulic Core Design of the Pebble Bed Reactor	R	2015-11	08.01.2016	1984-03	-	-
(3104)	Shutdown Systems for Light Water Reactors	SR	1979-10	19 a - 29.01.1980 Suppl. 1/80	-	27.03.84; 27.06.89; 14.06.94; 15.06.99; 16.11.04; 10.11.09	+
3107	Determination of the Shutdown Reactivity	R	2014-11	15.01.2015	-	-	-
<u>3200 Primary and secondary coolant circuit</u>							
3201.1	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 1: Materials and Product Forms	ÄE	2016-11	22.12.2016	1979-02; 1982-11; 1990-06; 1998-06	-	-
3201.2	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 2: Design and Analysis	R	2013-11	17.01.2014	1980-10; 1984-03 1996-06	-	+
3201.3	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 3: Manufacture	R	2007-11	9 a - 17.01.2008 Amendment 82a - 05.06.09	1979-10; 1987-12; 1998-06	13.11.12	+
3201.4	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 4: Inservice Inspections and Operational Monitoring	R	2016-11	10.03.2017	1982-06; 1990-06; 1999-06; 2010-11	-	+

Standard No. KTA	Title	Status	Last version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	Engl. Transl.
3203	Surveillance of the Irradiation Behaviour of Reactor Pressure Vessel Materials of LWR Facilities	R	2001-06	235 b - 15.12.2001	1984-03	07.11.06; 15.11.11	+
3204	Reactor Pressure Vessel Internals	R	2015-11	29.04.2016	1984-03; 1998-06; 2008-11	-	-
3205.1	Component Support Structures with Non-integral Connections; Part 1: Component Support Structures with Non-integral Connections for Components of the Reactor Coolant Pressure Boundary of Light Water Reactors	R	2002-06	189 a - 10.10.2002	1982-06; 1991-06	13.11.07	+
3205.2	Component Support Structures with Non-integral Connections; Part 2: Component Support Structures with Non-Integral Connections for Pressure and Activity-Retaining Components in Systems Outside the Primary Circuit	R	2015-11	08.01.2016 Amendment 29.04.2016	1990-06	-	-
3205.3	Component Support Structures with Non-integral Connections; Part 3: Series-Production Standard Supports	R	2006-11	163 a - 31.08.2007	1989-06	15.11.11	+
3206	Verification Analysis for Rupture Preclusion for Pressure Retaining Components in Nuclear Power Plants	R	2014-11	15.01.2015 Amendment 26.11.2015	-	-	-
3211.1	Pressure and Activity Retaining Components of Systems Outside the Primary Circuit; Part 1: Materials	R	2015-11	08.01.2016	1991-06; 2000-06	-	-
3211.2	Pressure and Activity Retaining Components of Systems Outside the Primary Circuit; Part 2: Design and Analysis	R	2013-11	17.01.2014	1992-06	-	+
3211.3	Pressure and Activity Retaining Components of Systems Outside the Primary Circuit; Part 3: Manufacture	R	2012-11	02.05.2013 Amendment 29.04.2016	1990-06; 2003-11	-	+

Standard No. KTA	Title	Status	Last version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	Engl. Transl.
3211.4	Pressure and Activity Retaining Components of Systems Outside the Primary Circuity; Part 4: Inservice Inspections and Operational Monitoring	R	2013-11	29.04.2014	1996-06; 2012-11	-	+
<u>3300 Heat removal</u>							
3301	Residual Heat Removal Systems of Light Water Reactors	R	2015-11	08.01.2016	1984-11	-	-
3303	Heat Removal Systems for Fuel Assembly Storage Pools in Nuclear Power Plants with Light Water Reactors	R	2015-11	08.01.2016	1990-06	-	-
<u>3400 Reactor containment</u>							
3401.1	Steel Containment Vessels; Part 1: Materials	R	1988-09	37 a - 22.02.1989	1980-06; 1982-11	15.06.93; 16.06.98	+
3401.2	Steel Containment Vessels; Part 2: Analysis and Design	R	2016-11	10.03.2017	1980-06; 1985-06	-	-
3401.3	Steel Reactor Safety Containment; Part 3: Manufacture	R	1986-11	44 a - 05.03.1987	1979-10	23.06.92; 10.06.97	+
3401.4	Steel Containment Vessels; Part 4: Inservice Inspections	ÄE	2016-11	22.12.2016	1981-03; 1991-06	-	-
3402	Airlocks on the Reactor Containment of Nuclear Power Plants - Personnel Airlocks	R	2014-11	06.05.2015	1976-11; 2009-11	-	-
3403	Cable Penetrations through the Reactor Containment Vessel	R	2015-11	29.04.2016	1976-11; 1980-10; 2010-11	-	-
3404	Isolation of Operating System Pipes Penetrating the Containment Vessel in the Case of a Release of Radioactive Substances into the Containment Vessel of Nuclear Power Plants	R	2013-11	29.04.2014	1988-09; 2008-11	-	+
3405	Leakage Test of the Containment Vessel	R	2015-11	29.04.2016	1979-02; 2010-11	-	-
3407	Pipe Penetrations through the Reactor Containment Vessel	R	2014-11	06.05.2015	1991-06	-	-
3409	Airlocks on the Reactor Containment of Nuclear Power Plants - Equipment airlocks	R	2009-11	72 a - 12.05.2010	1979-06	11.11.14	+

Standard No. KTA	Title	Status	Last version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	Engl. Transl.
3413	Determination of Loads for the Design of a Full Pressure Containment Vessel against Plant-Internal Incidents	R	2016-11	10.03.2017	1989-06	-	-
3500 Reactor protection system							
3501	Reactor Protection System and Monitoring Equipment of the Safety System	R	2015-11	08.01.2016	1977-03; 1985-06	-	-
3502	Accident Measuring Systems	R	2012-11	23.01.2013	1982-11; 1984-11; 1999-06	-	+
3503	Type Testing of Electrical Modules for the Safety Related Instrumentation and Control System	R	2015-11	08.01.2016	1982-06; 1986-11; 2005-11	-	-
3504	Electrical Drive Mechanisms of the Safety System in Nuclear Power Plants	R	2015-11	29.04.2016	1988-09; 2006-11	-	-
3505	Type Testing of Measuring Sensors and Transducers of the Safety-Related Instrumentation and Control System	R	2015-11	08.01.2016	1984-11; 2005-11	-	-
3506	System Testing of the Instrumentation and Control Equipment Important to Safety of Nuclear Power Plants	ÄE	2016-11	22.12.2016	1984-11; 2012-11	-	-
3507	System Testing of the Instrumentation and Control Equipment Important to Safety of Nuclear Power Plants	R	2014-11	15.01.2015	1986-11; 2002-06	-	-
3600 Activity control							
3601	Ventilation Systems in Nuclear Power Plants	ÄE	2016-11	22.12.2016	1990-06; 2005-11	-	-
3602	Storage and Handling of Fuel Assemblies and Associated Items in Nuclear Power Plants with Light Water Reactors	R	2003-11	26 a - 07.02.2004	1982-06; 1984-06; 1990-06	11.11.08; 19.11.13	+
3603	Facilities for Treating Radioactively Contaminated Water in Nuclear Power Plants	ÄE	2016-11	22.12.2016	1980-02; 1991-06; 2009-11	-	-

Standard No. KTA	Title	Status	Last version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	Engl. Transl.
3604	Storage, Handling and Plant-internal Transport of Radioactive Substances in Nuclear Power Plants (with the Exception of Fuel Assemblies)	R	2005-11	101 a - 31.05.2006	1983-06	16.11.10	+
3605	Treatment of Radioactively Contaminated Gases in Nuclear Power Plants with Light Water Reactors	ÄE	2016-11	22.12.2016	1989-06; 2012-11	-	-
<u>3700 Power and media supply</u>							
3701	General Requirements for the Electrical Power Supply in Nuclear Power Plants	R	2014-11	15.01.2015	KTA 3701.1: (1978-06); KTA 3701.2: (1982-06); 1997-06; 1999-06	-	-
3702	Emergency Power Generating Facilities with Diesel-Generator Units in Nuclear Power Plants	R	2014-11	15.01.2015	KTA 3702.1: (1980-06); KTA 3702.2: (1991-06); 2000-06	-	-
3703	Emergency Power Facilities with Batteries and AC/DC Converters in Nuclear Power Plants	R	2012-11	23.01.2013	1986-06; 1999-06	-	-
3704	Emergency Power Facilities with Static and Rotating AC/DC Converters in Nuclear Power Plants	R	2013-11	17.01.2014	1984-06; 1999-06	-	-
3705	Switchgear Facilities, Transformers and Distribution Networks for the Electrical Power Supply of the Safety System in Nuclear Power Plants	R	2013-11	29.04.2014	1988-09; 1999-06; 2006-11	-	-

Standard No. KTA	Title	Status	Last version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	Engl. Transl.
3706	Ensuring the Loss-of-Coolant-Accident Resistance of Electrotechnical Components and of Components in the Instrumentation and Controls of Operating Nuclear Power Plants	R	2000-06	159 a - 24.08.2000	-	22.11.05; 16.11.10; 10.11.15	+
<u>3900 Other systems</u>							
3901	Communication Means for Nuclear Power Plants	ÄE	2016-11	22.12.2016	1977-03; 1981-03; 2004-11; 2013-11	-	-
3902	Design of Lifting Equipment in Nuclear Power Plants	R	2012-11	23.01.2013; Amendment 02.05.2013	1975-11; 1978-06; 1983-11; 1992-06; 1999-06	-	+
3903	Inspection, Testing and Operation of Lifting Equipment in Nuclear Power Plants	R	2012-11	23.01.2013; Amendment 02.05.2013	1982-11; 1993-06; 1999-06	-	+
3904	Control Room, Remote Shutdown Station and Local Control Stations in Nuclear Power Plants	ÄE	2016-11	22.12.2016	1988-09; 2007-11	-	-
3905	Load Attaching Points on Loads in Nuclear Power Plants	R	2012-11	23.01.2013	1994-06 1999-06	-	+

R	Safety Standard
RE	Draft Safety Standard
ÄE	Draft Safety Standard of an existing Safety Standard (Revision)
REV	Draft Safety Standard in Preparation
ÄEV	Draft Revised Safety Standard in Preparation
VB	Primary Report
SR	Inactive Safety Standard (Safety standard no longer included in the reaffirmation process acc. sec. 5.2 of the procedural statutes)
ZR	Withdrawn Safety Standard (Safety Standard withdrawn by decission of the KTA)

(e) Other documents to be considered

These documents have to be considered by the competent authorities in licensing and supervision as and when required.

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Additional report concerning the remediation of the Wismut GmbH

Wismut-Annex

to the

Report of the Federal Republic of Germany for the Sixth Review Meeting of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (IAEA Joint Convention), May 2018

1 The Wismut remediation project: starting point and scope

For more than 25 years now, the state-owned Wismut GmbH company has been cleaning up the legacies from the former uranium ore mining activities of what used to be the Soviet-German Joint-Stock Company (Sowjetisch-Deutsche Aktiengesellschaft – SDAG) Wismut. From 1946 until the end of 1990, the latter extracted a total of 231,000 t of uranium in eastern Germany making it the fourth largest uranium producer of its time worldwide. Among the legacies of the SDAG Wismut were 32 km² of facility areas, five uranium mines with a total of approx. 1,500 km of open-cast mine workings, an abandoned open-cast mine with an open volume of 84 million m³, 48 heaps with a volume of low active rocks of approx. 311 million m³, four tailings ponds holding a total of 160 million m³ of radioactive sludges, and two processing factories for uranium ore.

The locations embraced by the Wismut remediation project span from Königstein in the eastern part of the *Land* of Saxony to Dresden-Gittersee, Schlema-Alberoda and Pöhla up to Crossen in western Saxony. In the *Land* of Thuringia, they include the Ronneburg and Seelingstädt sites. Details about the situation after uranium ore exploitation in Saxony and Thuringia was abandoned, the dimension of the Wismut project, the legal basis of the project regarding radiation protection, and the remediation technologies have already been described comprehensively in the reports to the previous review meetings.

In 2015, a review was carried out on the status of remediation. With this 2015 Remediation Programme, the remaining remediation tasks, including long-term tasks in the time horizon 2016 to 2045, were re-evaluated in terms of content and financing.

2 Status of remediation

Remediation of the legacies of uranium ore mining at the Wismut sites was continued successfully during the review period. For the entire project, funding of around 8 billion euros are to be provided by the Federal Republic of Germany on the basis of the Remediation Programme 2015. Around 6 billion euros (approx. 75 %) have been used up by the end of 2015.

<u>Underground remediation</u>

Underground remediation has almost been completed. In the Schlema-Alberoda mine, underground work is still outstanding. The activities focus on the creation and maintenance of pathways for the directed drainage of mine waters and ventilation.

Excavation of the Wismut tunnel for draining the mine waters of the Dresden-Gittersee mine and of the bypass drift for the drainage tunnel in the Schlema-Alberoda mine, which runs through geologically unstable rock, were completed.

Remediation of heaps

The heaps at the Dresden-Gittersee and Pöhla sites have been completely remediated. At Schlema-Alberoda, all heaps that are no longer managed are now remediated, with the exception of heaps 309 and 310. At the Ronneburg site, the relocation of the heaps to the abandoned open-cast mine at Lichtenberg has been completed. Around 98 % of the resulting backfill volume is covered now.

The profiling and covering of heap 371 at the Schlema-Alberoda site and of the Schüsselgrund heap at the Königstein site was continued. During the course of the management of both heaps, residues from the treatment of contaminated mine waters, heap waters and leachate will continue to be emplaced for several decades to come. The areas needed for emplacement (approx. 5 % of the total area of heap 371; approx. 20 % of the total area of the Schüsselgrund heap) will only be finally covered once water treatment at the sites has ceased. Current knowledge suggests that periods of more than 50 years can be expected in this respect.

Dismantling of facilities, area rehabilitation and remediation of industrial tailing ponds

In the period under review, the work on the dismantling of facilities and area rehabilitation continued continuously, for example by the demolition of the head frames of shafts 388 and 390 at the Königstein site. The main focus of the work was again on the remediation of the industrial tailing ponds. Details about the progress made during the review period are given in Tab. 1.

Tab. 1: Comparison of selected figures showing the status of remediation

	End of 2015		**End of 03/2017**	
	absolute	relative[1)]	absolute	relative[1)]
Abandoned mine workings	1,467 km	100 %	1,467 km	100 %
Rehabilitated shafts/entrances	1.4 Mio. m³	99 %	1.4 Mio. m³	100 %
Backfilled mine workings	239,800 m³	99 %	243,000 m³	99 %
Relocation of material to industrial tailings ponds	19.3 Mio. m³	74 %	20.8 Mio. m³	63 %
Final covering of the industrial tailings ponds	5.0 Mio. m³	46 %	5.3 Mio. m³	52 %
Material from decommissioning of facilities	1.0 Mio. m³	88 %	1.0 Mio. m³	81 %
Remediated facility areas	1,163 ha	81 %	1,168 ha	86 %

1) related to overall Wismut remediation

Flooding of the mines and water treatment

The status of flooding of the uranium mines of the Wismut company still varies from mine to mine. At Pöhla, the natural filling level was already reached in 1995. At Dresden-Gittersee, flooding has been completed with the commissioning of the "Wismut-Stollen" in 2014. At the Königstein, Ronneburg and Schlema-Alberoda sites, intensive uplift and treatment of mine waters is still ongoing in order to be able to carry out a controlled flooding of the mines. At the same time, leachate from heaps is also treated in the on-site water treatment plants. The water treatment plants at the Seelingstädt and Crossen sites treat not only the surplus water but also the leachate and pore waters from industrial tailing ponds.

At Schlema-Alberoda, the large total volume of the water to be treated (in wet years up to around 1,000 m³/h) and the high pollutant concentration in the residues of water treatment require considerable technical and financial efforts.

At Ronneburg, the water treatment plant has been operated with increased capacity (850 m³/h) since September 2011 without any failures. This has helped lowering the groundwater level and reducing or preventing groundwater emergence at the surface. During further lowering of the groundwater level, Wismut has started and largely completed work on the optimisation of local water collection systems.

For the Königstein mine, in which uranium ore was leached underground, the flooding variant applied for by Wismut – filling up to the natural final level at about 190 m sea level – had not been approved by the competent authorities. Wismut has appealed against this rejection. Presently, it is to be expected that the water level in the mine will have to be kept at a licensed level of 140 m sea level in the longer term. Thus, it is to be assumed that contaminated mine water will have to be uplifted and treated over a very long period of time.

3 Presentation of selected remediation results

The past reports have already illustrated by way of examples the progress made in improving the environmental situation as well as the reuse of remediated objects. The following figures show some aspects of the remediation activities during the reporting period.

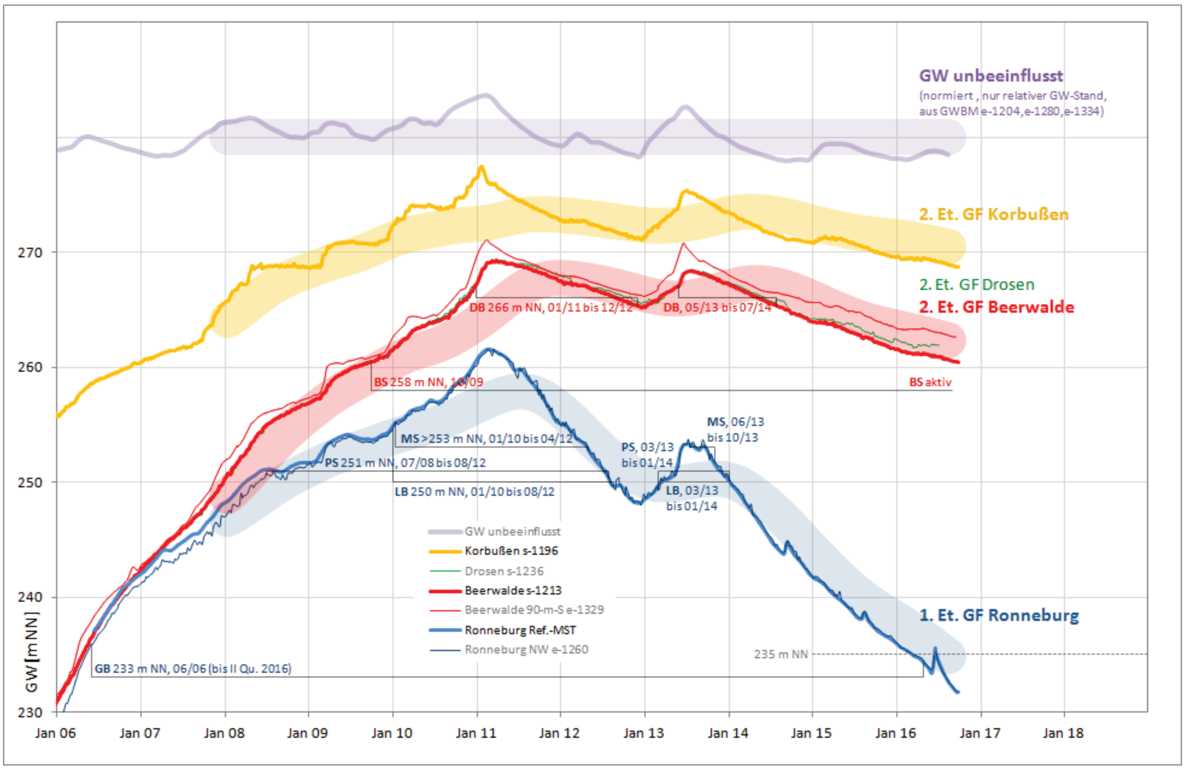

Fig. 1: Course of flooding in the Ronneburg mine fields during the current lowering phase

Fig. 2: Dismantling and demolition of shafts 388/390 at the Königstein site (2014/2015, copyright: Archive Wismut)

Fig. 3: Covering of heap 309 in Bad Schlema completed (as of July 2016, copyright: Archive Wismut)

4 Long-term tasks and prospect

The long-term tasks of Wismut and their performance over time have already been described in detail in the reports to the third, fourth and fifth review meetings. Some of the tasks that have already been undertaken include

- inspection, repair, maintenance and care of covers,
- treatment of flooding waters and leachate,
- stability of near-surface mine workings,
- mitigation of mining damage,
- long-term environmental monitoring, and
- preservation and maintenance of remediation documentation.

For the preservation of the know-how of the Wismut remediation and the efficient continuation of the data and information management (i.a. within the framework of long-term monitoring and for institutional control in the long term), the internal data and information centre (Daten- und Informationszentrum – DIZ) continued its work.

With a re-assessment of the remediation programme in 2015, the time and funds needed for the final remediation by Wismut have been further specified. According to current knowledge, the core remediation process is to be completed in 2028. The current plans for long-term tasks extend to the year 2045.